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| **Radiocommunication Study Groups** |  |
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| Subject: IMT-2020 Evaluation | Document 5D/457-E |
| 22 January 2025 |
| English only  TECHNOLOGY ASPECTS |
| Director, Radiocommunication Bureau[[1]](#footnote-1)\* | |
| FInal evaluation Report from ARIB IMT-2020 Evaluation Group on the IMT-2020 proposal in Document IMT-2020/89 by “Nufront” IN THE IMT-2020 EVALUATION PROCESS | |
|  | |

This document describes the final evaluation results and activities by ARIB IMT-2020 Evaluation Group regarding the IMT-2020 candidate technology submission in Document [IMT-2020/89](https://www.itu.int/md/R15-IMT.2020-C-0089/en) by “Nufront”. The candidate technology was evaluated in the Step 4 of the IMT-2020 development process.

Part I

Administrative aspects of the Independent Evaluation Group

# 1 Name of the Independent Evaluation Group

IMT-2020 Evaluation Group, ARIB IMT-2020 Evaluation Group (ARIB IEG)

# 2 Introduction and background of the Independent Evaluation Group

The Association of Radio Industries and Businesses (ARIB) was established to promote research and development (R&D) of new radio systems, and to serve as a Standards Development Organization (SDO) to advance the unification of international standards and related activities in the telecommunications and broadcasting fields. In May 2024, ARIB IMT-2020 Evaluation Group (ARIB IEG) was established under Standardization subcommittee of Advanced Wireless Communications Study Committee (ADWICS) in ARIB as an Independent Evaluation Group (IEG) committing in the process of IMT-2020 evaluation.

ARIB IEG has submitted the interim evaluation report in Working Party (WP) 5D #47 meeting in October 2024, for Dense-Urban and Indoor Hotspot test environments of eMBB usage scenarios ([Document IMT-2020/90](https://www.itu.int/md/R15-IMT.2020-C-0090/en)). After WP 5D #47 meeting, ARIB IEG provided a response in “Evaluation group discussion area” to comments from the proponents on the interim evaluation report (Annex C). ARIB IEG concluded that the ARIB IEG’s technical understanding on the proposed technology submission in Doc. IMT-2030/89 remains unchanged even after the above correspondences with the proponent, therefore, the same evaluation results in the interim evaluation report are kept in this final evaluation report.

In this contribution, ARIB IEG submits the final evaluation results, for Dense-Urban and Indoor Hotspot test environments of eMBB usage scenario and Urban Macro test environment of mMTC/URLLC usage scenarios.

# 3 Method of work

The evaluation method in this report is in line with what are suggested in Report ITU-R M.2412-0 that are inspection, analysis and simulation.

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# 6 Other pertinent administrative information

None.

Part II

Technical aspects of the work of the Independent Evaluation Group

# A) Evaluated candidate technologies for IMT-2020

This report is the final evaluation report on EUHT, as the candidate RIT technology submitted in Document IMT-2020/89.

# B) Utilization of ITU-R evaluation guidelines

This final evaluation report contains evaluations performed in accordance with Report ITU‑R M.2412‑0.

# C) Documentation of any additional evaluation methodologies

There are no additional evaluation methodologies developed to complement the evaluation guidelines in Report ITU-R M.2412-0.

# D) Verification as per Report ITU-R M.2411 of the compliance templates

# 1 Gaps/deficiencies in submitted material and/or self-evaluation

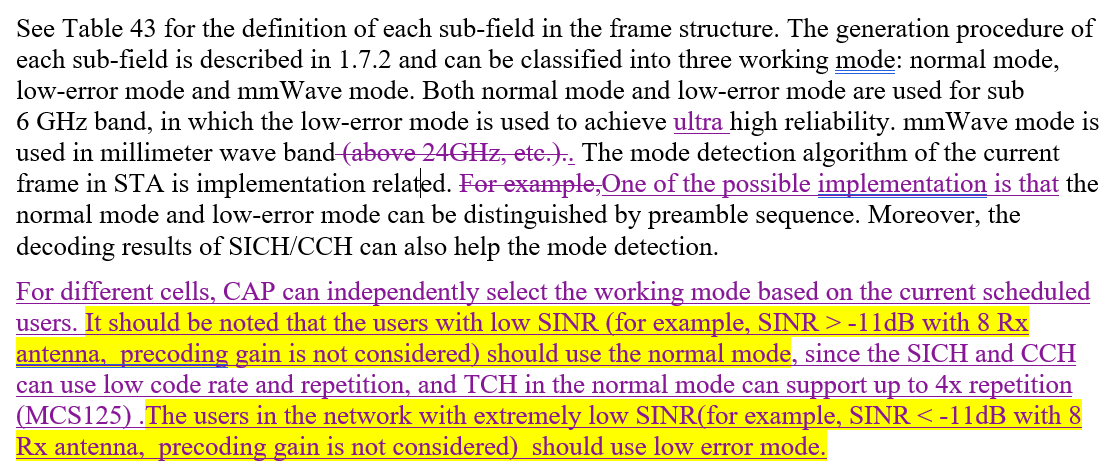
First of all, comparing that Document IMT-2020/18(Rev.1) in 2019 or IMT-2020/76 in 2022 that proposed to support a maximum of 8 or 16 antenna number, the EUHT specification in Document IMT-2020/89 proposed to support the maximum antenna number as 32. So accordingly, ARIB IEG’s evaluation has considered the increase of the number of antennas. In addition, ARIB IEG’s evaluation has also taken into account the channel condition measurement and feedback under such antenna number, system overhead and other factors. The Multi-User (MU) pairing algorithm for capacity maximization has been used in eMBB Downlink simulation, which are aligned with the self-evaluation report in Document IMT-2020/89.

After analysing the simulation results, several issues have been identified in the submitted specification of EUHT technology and its corresponding self‑evaluation and these are discussed in the following sections.

## 1.1 EUHT dynamic mode switching for eMBB evaluation

ARIB IEG has also constructed the simulation model of dynamic switching with normal and low-error modes into system-level simulation. Then ARIB IEG has observed that EUHT technology cannot meet the IMT-2020 requirements, especially average spectral efficiency at UL and 5th percentile user spectral efficiency at DL and UL, in Indoor Hotspot-eMBB, and Dense Urban-eMBB, according to the results.

According to the EUHT specification of IMT-2020/89 below (section 1.7.1.1 Frame structure), dynamic mode switching feature of IMT-2020/89 is added with the switching decision criteria by using SINR threshold, which is different from the IMT-2020/18(Rev.1) and IMT-2020/76. Therefore, our current evaluation follows this guidance in the EUHT specification in IMT-2020/89 (as shown as below).



In the EUHT specification, cell-specific short preamble is used for the mode selection. So, the dynamic mode switching is a feature per cell, not a feature per user. If the format of short preamble is changed between “normal mode” and “low error mode” by CAP, all STAs in this cell have to switch into the corresponding mode for receiving long preamble, SICH, CCH and TCH, after successful detection of short-preamble. Hence, a cell is in one mode in one frame according to EUHT specification.

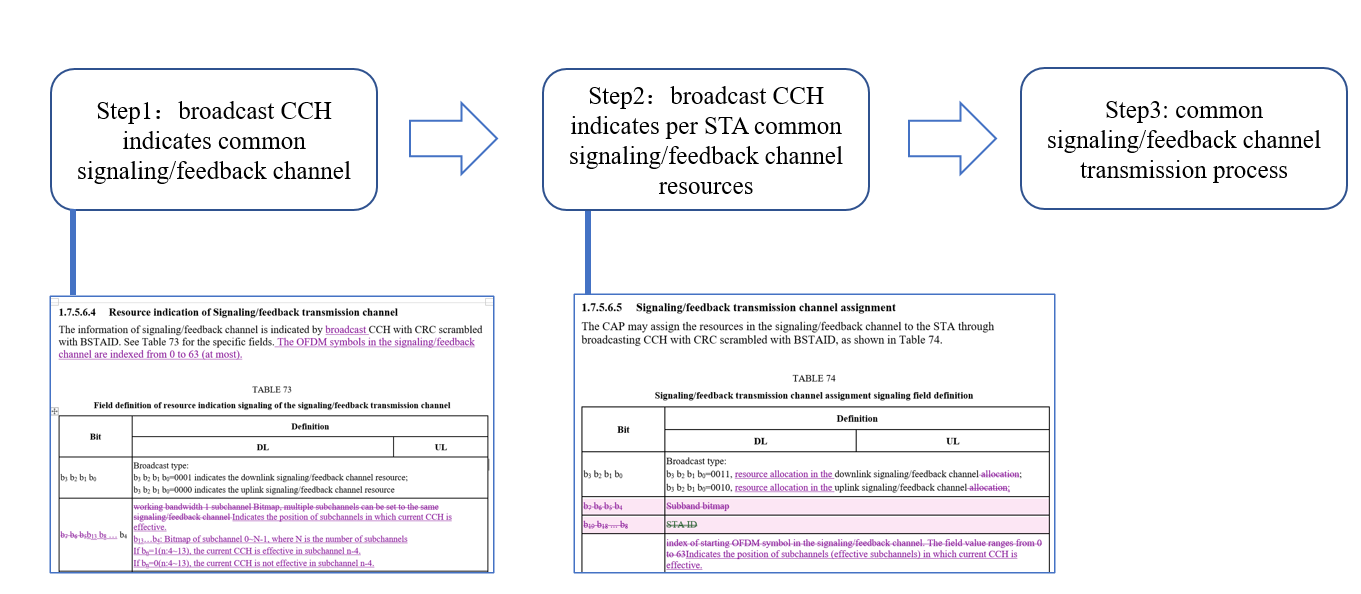
Regarding the dynamic mode switching feature of EUHT technology in IMT-2020/89, ARIB IEG has observed in the simulation that the cell rarely switches to low-error mode according to the SINR threshold of EUHT specification in IMT-2020/89.

When the cell switches to low-error mode, all STAs in the cell switch to low-error mode, the spectral efficiency would be significantly decreased because in this mode there are few MCS candidates, single stream transmission but without MU-MIMO. Therefore the degradation of spectral efficiency due to low-error mode is difficult to be resolved by the scheduler.

The following is the comparison of the low-error mode feature of EUHT specifications submitted in different EUHT specifications.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | Low-error mode in IMT-2020/18(Rev.1) | Low-error mode in IMT-2020/76 | Low-error mode in IMT-2020/89 |
| SICH | | integrated into CCH | Same as IMT-2020/18(Rev.1) | Same as IMT-2020/76 |
| CCH | | Support frequency and time domain rep | Same as IMT-2020/18(Rev.1) | Same as IMT-2020/76 |
| TCH | Modulation | QPSK | Same as IMT-2020/18(Rev.1) | Six QPSK candidates  One 16QAM candidate  One 64QAM candidate |
| Code rate | 1/2，4/7 | 4/7 | Same as IMT-2020/76 |
| Code length | 448 | Same as IMT-2020/18(Rev.1) | Same as IMT-2020/76 |
| Repetition | Support 1-32 times repetition | DL: 4-16 times repetition  UL: 4-24 times repetition | DL and UL:  QPSK with {no, 2, 3, 4, 8, 12} times repetition |
| MIMO | MU-MIMO | Not support | Same as IMT-2020/18(Rev.1) | Same as IMT-2020/76 |
| Stream number | 1 | Same as IMT-2020/18(Rev.1) | Same as IMT-2020/76 |
| Code word number | 1 | Same as IMT-2020/18(Rev.1) | Same as IMT-2020/76 |

When the cell switches to normal mode, the reliability of cell-edge STA’s transmission is not good. ARIB IEG observed that the CCH and TCH transmission in EUHT specification was not reliable enough, there would be a high probability of the miss-detection of broadcast/dedicated CCH and TCH for cell-edge STA with low SINR. As below shown in the feedback channel process of IMT-2020/89 that is the same as IMT-2020/76, so the observation of the feedback channel should be the same as before, such as the indication of resource pool and also the indication of the common signalling/feedback channel may be missed.



It shall be noted that the ARIB’s simulations have not considered the impact of false preamble detection possibility of dynamic mode switching and false blind CCH detection possibility, which will further degrade the performance.

Considering the above analysis and results, ARIB IEG has concluded that dynamic switching feature of EUHT technology would degrade the spectral efficiency. It is one of the reasons that EUHT technology cannot meet the IMT-2020 requirements of UL average spectral efficiency and 5th percentile user spectral efficiency at DL and UL.

## 1.2 EUHT signaling/feedback transmission for eMBB evaluation

After ARIB IEG constructs the models of signaling/feedback channel into system-level simulation, ARIB IEG has observed that EUHT technology did not meet the IMT-2020 requirements of UL average spectral efficiency, DL and UL 5th percentile user spectral efficiency in Indoor Hotspot-eMBB, and Dense Urban-eMBB, according to the results.

The EUHT specification of IMT-2020/89 about signaling/feedback channel had small changes as summarized in the table below. This change may reduce the overhead, if there is some control region resources unused by CCH. But the new changes did not improve the reliability issue of signaling/feedback channel as pointed out in Document [5D/1412](https://www.itu.int/md/R19-WP5D-C-1412/en). The non-ideal signaling/feedback channel performance has been constructed in the evaluation. For the feedback/signaling channel, due to the impact on the user plane and thereby spectral efficiency, the results of spectral efficiency are further reduced as the explanation in Document [5D/756](https://www.itu.int/md/R19-WP5D-C-0756/en).

The following is the comparison of the signalling/feedback channel submitted in different EUHT specifications.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | EUHT specification of IMT-2020/18(Rev.1) | EUHT specification of IMT-2020/76 | EUHT specification of IMT-2020/89 |
| Signaling/feedback information is transmitted in traffic channel |  | Be grouped with other MAC frames | Be grouped with other MAC frames | Same as IMT-2020/76 |
| Dedicated signaling/ feedback channel |  | Transmission scheme is the same as the one used by common signaling /feedback channel in IMT-2020/18(Rev.1) | Transmission scheme is the same as the one used by TCH in IMT-2020/76 |
| Common signaling/ feedback channel | Modulation | QPSK | Indicated in broadcast CCH,  as one of BPSK, QPSK..., 256QAM |
| Code rate | 1/2 | Indicated in broadcast CCH,  as one of 1/2, 3/4, 4/7... and 7/8 |
| Coding Type | Convolutional code | Same as IMT-2020/18(Rev.1) |
| Number of streams | Single stream |
| Demodulation Reference Signal | DPIF = 1 |
| Transmission mode | Open loop MIMO |
| Repetition | N/A | 3 or 4 time-domain repetitions, when MCS is 122 or 123 | Same as IMT-2020/76,  • MCS 124 (same with MCS 122 in IMT‑2020/76);  • MCS 125 (same with MCS 123 in IMT‑2020/76) |
| Occupied resource | Dedicated resource | Dedicated resource | Dedicated resource, in addition, which can use the subchannel-level resource if these subchannel-level resource is not occupied by CCH. |

In addition, ARIB IEG has observed that the success rate of receiving TCH is degraded and system overhead is increased after constructing the models of signaling/feedback channel into the simulator.

Considering the above analysis and results, ARIB IEG has concluded that signaling/feedback channel performance of EUHT technology would degrade the spectral efficiency. It is one of the reasons that EUHT technology cannot meet the requirements of UL average spectral efficiency, and 5th percentile user spectral efficiency in DL and UL.

## 1.3 Dynamic system overhead for eMBB evaluation

5GMF IEG has constructed the model of dynamic system overhead into system-level simulation for evaluating IMT-2020/76 in 2022.

This time ARIB IEG constructed the model of dynamic system overhead too. Here, dynamic overhead means that the system overhead in each simulation frame will change, by applying with realistic modeling of CCH types, CCH number, signaling/feedback information amount and etc. The implementation of dynamic system overhead is illustrated in the following figure.

A picture containing text

Description automatically generated

Compared with EUHT specification of IMT-2020/76 in 2022, more reliable channel design for broadcast CCH is introduced in the EUHT specification of IMT-2020/89, as shown in the table below. However, the changes would also bring some disadvantages, as CCH/ transmission then needs more time-frequency resources of the EUHT system, which bring extra system overhead. This impact is considered in the ARIB IEG’s evaluation.

In this similar observation, the CCH performance (Type I CCH) in IMT-2020/18(Rev.1) was proved to degrade the spectral efficiency in 5D/740. So, the probability of using Type II/III CCH introduced in IMT-2020/89 for TCH should be high, because the performance of Type I CCH is not good enough. Then, by introducing these Type II/III CCHs, the increased overhead will then decrease the spectral efficiency, according to the results.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Normal mode in IMT-2020/18(Rev.1) | Normal mode in IMT-2020/76 | Normal mode in IMT-2020/89 |
| SICH | Type I SICH BPSK 1/2, and No rep | Same as IMT-2020/18(Rev.1) | Same as IMT-2020/76 |
| N/A | Type II SICH with QPSK 3/14, and 2 time-domain rep | Same as IMT-2020/76 |
| CCH | Type I CCH for indicating TCH and dedicated signaling feedback channel QPSK 4/7 and No rep | Same as IMT-2020/18(Rev.1) | Same as IMT-2020/76 |
| N/A | Type II CCH for indicating TCH with QPSK 3/14 and No rep  Type III CCH for 2 time-domain rep of Type II CCH | Same as IMT-2020/76 |
| The broadcast CCHs for common signaling feedback channels | Same as IMT-2020/18(Rev.1) | Using Transmission CCH Type-II/III |
| Long preamble (CRS) | Type I long preamble in one symbol | Same as IMT-2020/18(Rev.1) | Same as IMT-2020/76 |
| N/A | Type II long preamble, which is Type I long preamble with 2 time-domain rep | Same as IMT-2020/76 |

In addition, it shall be noted that the successful transmission of SICH/CCH/Long preamble (CRS) depends on STA detection performance. If any one of them was detected incorrectly, it will lead to the TCH transmission failure. Current ARIB’s evaluation has not taken into account the false detection possibility of SICH/CCH/Long preamble (CRS) yet.

Considering the above analysis and results, ARIB IEG has concluded that new types of broadcast CCH transmission and SICH/CCH/Long preamble (CRS) that required more resources, would degrade the spectral efficiency. It is one of the reasons that EUHT technology cannot meet the IMT‑2020 requirements of UL average spectral efficiency and 5th percentile user spectral efficiency in DL and UL.

## 1.4 Reliability for URLLC evaluation

ARIB IEG has constructed the model of low-error mode long preamble and uplink RS design into system-level and link-level simulation for evaluating IMT-2020/89 in 2024. The related contents of section 1.7.3 Preamble sequence in EUHT specification of IMT-2020/89 are as below:

|  |
| --- |
| 1.7.3 Preamble sequence Long Preamble (CRS): |

|  |
| --- |
| 1.7.5.3 Traffic channel demodulation reference signal |

Compared with EUHT specification of IMT-2020/76 in 2022, new preamble design is introduced in the EUHT specification of IMT-2020/89, as shown in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Reference signal in low-error mode in IMT-2020/18(Rev.1)** | **Reference signal in low-error mode in IMT-2020/76** | **Reference signal in low-error mode in IMT-2020/89** |
| Long preamble (CRS) | 4 frequency domain phase shifts stated by proponent, but it is not clear to specify in low-error mode in the specification of IMT-2020/18(Rev.1). | 8 time-domain phase shifts (PN sequences) | 8 shifts x 8 candidate sequences |
| Uplink DRS | As same as the IMT-2020/18(Rev.1) Long preamble (CRS) | As same as the IMT-2020/76 Long preamble (CRS) with 2 time-domain rep | As same as the IMT-2020/89 Long preamble (CRS) with 2 time-domain rep |

However, the changes of EUHT specification of IMT-2020/89 also include the repetition number. The maximum repetition number of low-error mode in IMT-2020/89 is smaller than the IMT-2020/76, which will degrade the performance in URLLC scenario.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Modulation and coding in low-error mode in IMT-2020/18(Rev.1)** | **Modulation and coding in low-error mode in IMT-2020/76** | **Modulation and coding in low-error mode in IMT-2020/89** |
| CCH | Support frequency and time domain rep | Same as IMT-2020/18(Rev.1) | Same as IMT-2020/76 |
| Downlink  TCH | LDPC with code rate = 4/7, QPSK, Repetition 12 stated by proponent\*, but it is not clear to specify in low-error mode in the specification of IMT-2020/18(Rev.1). | LDPC with code rate = 4/7, QPSK, Repetition 16, which is 4 time-domain rep \* 4 frequency-domain rep | LDPC with code rate = 4/7, QPSK, Repetition 12, which is 3 time-domain rep \* 4 frequency-domain rep |
| Uplink  TCH | LDPC with code rate = 4/7, QPSK Repetition 8 stated by proponent\*, but it is not clear to specify in low-error mode in the specification of IMT-2020/18(Rev.1). | LDPC with code rate = 4/7, QPSK, Repetition 24 , which is 6 time-domain rep \* 4 frequency-domain rep | LDPC with code rate = 4/7, QPSK, Repetition 12 , which is 3 time-domain rep \* 4 frequency-domain rep |

ARIB IEG observed that the CCH and TCH transmission in EUHT specification was not reliable enough, there would be some probability of the miss-detection of CCH and TCH for cell-edge STA with low SINR, using above 12 TCH repetition number.

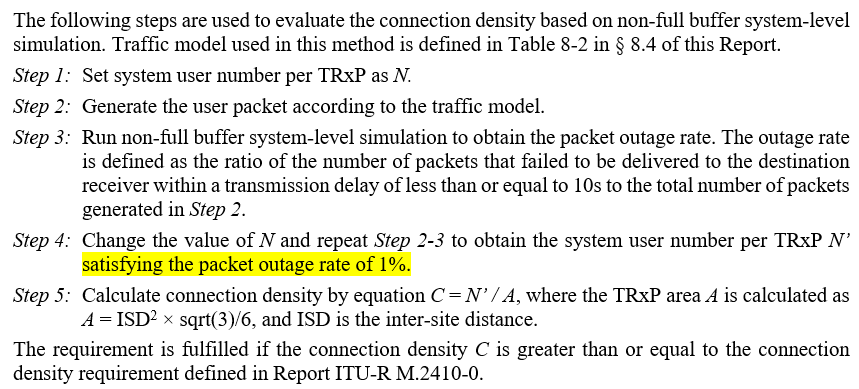
In addition, it shall be noted that the successful transmission of SICH/CCH/Long preamble (CRS) depends on STA detection performance. If any one of them was detected incorrectly, it will lead to the TCH transmission failure. Current ARIB IEG’s evaluation has not taken into account the false detection possibility of SICH/CCH/Long preamble (CRS) yet.

Considering the above analysis and results, ARIB IEG has concluded that new repetition design and current coding method would not be reliable enough. It is one of the reasons that EUHT technology cannot meet the IMT-2020 requirements of Reliability in DL and UL.

## 1.5 EUHT initial and transmission process for mMTC evaluation

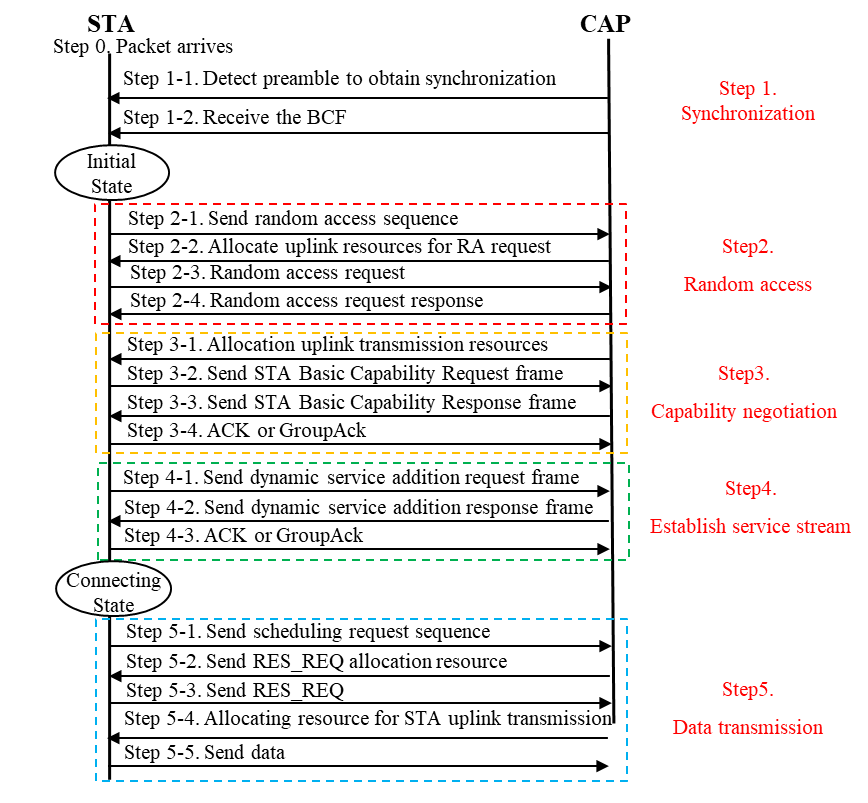
ARIB IEG has constructed the model of whole procedures of mMTC transmission into the system-level simulation for evaluating IMT-2020/89 in 2024.

Referring to section 7.1.3 of Report ITU-R M.2412, the non-full buffer system-level simulation method is utilized.



The synchronization, random access, capability negotiation, stream establishment, and data transmission procedures of EUHT specification of IMT-2020/89 are considered in the mMTC evaluation. The relevant processes are modelled based on the specification of IMT-2020/89.

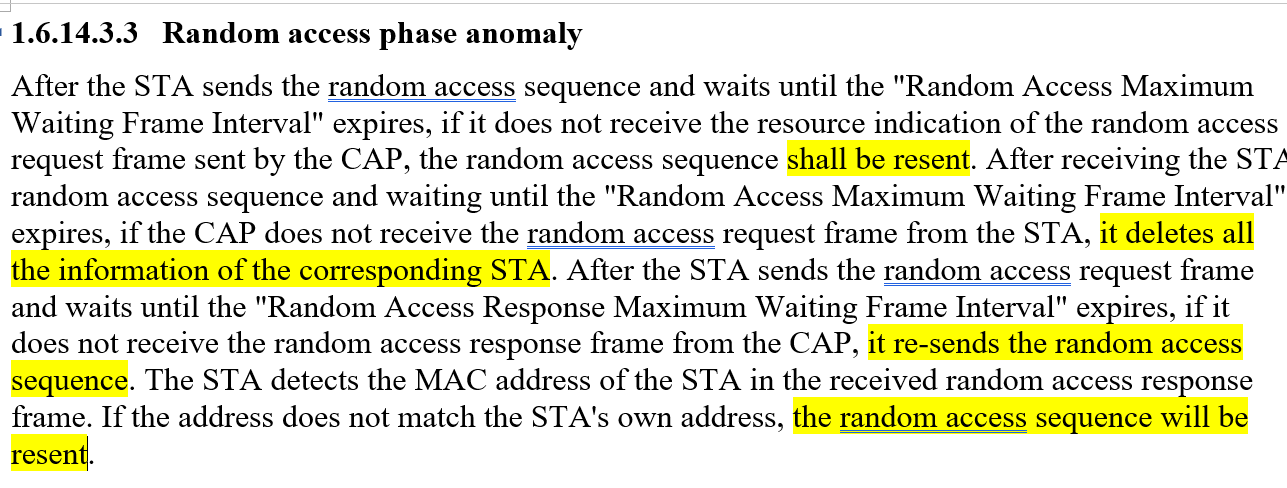
The detailed procedures are illustrated in the figure below.



ARIB IEG observed in the simulation that the connection density is smaller than 1 000 000 devices/km2 if the packet outage rate is small or equals to 1%, which means that EUHT cannot satisfy the minimum requirement of connection density specified in Report ITU-R M.2412. The detailed analysis is as below.

• Firstly, the above packet transmission procedure of EUHT specification is so long that introduces a large transmission delay, backoff delay and waiting delay, resulting in the packet transmission timeout for some packets (i.e. exceed the delay requirement 10s).

• Also, the recent implementation of the random-access backoff mechanism described in section 1.6.14.3.3 of IMT-2020/89 is likely to increase overall latency. This effect is particularly pronounced for cell-edge users, who already face a higher probability of transmission errors.



• In addition, the signaling/feedback channel transmission (e.g. carrying ACK) is currently designed exclusively for normal mode. As mentioned in the section 1.2, this design lacks sufficient reliability. An unreliable signaling or feedback channel can lead to increased overall delay, as the transmitter requires ACK confirmation to ensure successful transmission.

Furthermore, ARIB IEG assumed no delay to search the frequency, bandwidth and subcarrier spacing in the synchronization procedure. In this way, only preamble detection performance within serving cell is considered to impact the synchronization delay in current mMTC simulation.

Considering the above analysis and results, ARIB IEG has concluded that whole EUHT procedure in mMTC scenario would cause much delay and lead to packet outage. It is one of the reasons that EUHT technology cannot meet the IMT-2020 requirements of Connection Density.

# 2 Areas requiring clarifications

# 3 General questions

No specific questions that should be clarified were identified.

# E) Assessment as per Reports ITU-R M.2410, ITU-R M.2411 and ITU‑R M.2412

# 1 Provision of compliance template for services (section 5.2.4.1 of Report ITU-R M.2411-0)

|  |  |  |
| --- | --- | --- |
|  | **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) | As provided in this evaluation report, EUHT-5G RIT cannot support the usage scenarios of eMBB for configuration A/B/C in Indoor Hotspot-eMBB and configuration A/B in Dense Urban-eMBB, the usage scenario of URLLC for configuration A/B, and the usage scenario of mMTC for configuration A/B. |
| (1) As defined in Report ITU-R M.2410-0. | | |

# 2 Provision of compliance template for spectrum (section 5.2.4.2 of Report ITU-R M.2411-0)

|  |  |
| --- | --- |
|  | **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. |
| **As shown in Annex A-1, the following frequency bands are supported by EUHT-5G RIT, which contains certain frequency bands identified for IMT in the ITU Radio Regulations (Edition 2016).**  **EUHT-5G operating bands in Sub-6 GHz bands**   |  |  | | --- | --- | | Uplink (UL) and Downlink (DL) operating band | Duplex Mode | | 450-470 MHz | TDD | | 470-698 MHz | TDD | | 694/698-960 MHz | TDD | | 1 427-1 518 MHz | TDD | | 1 710-2 025 MHz | TDD | | 2 110-2 200 MHz | TDD | | 2 300-2 400 MHz | TDD | | 2 500-2 690 MHz | TDD | | 3 300-3 400 MHz | TDD | | 3 400-3 600 MHz | TDD | | 3 600-3 700 MHz | TDD | | 4 800-4 990 MHz | TDD | |
| **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.  NOTE 1 – In the case of the candidate SRIT, at least one of the component RITs need to fulfil this requirement. |
| **EUHT-5G operating bands in mmWave bands**   |  |  | | --- | --- | | Uplink (UL) and Downlink (DL) operating band | Duplex Mode | | 26 500 MHz-29 500 MHz | TDD | | 24 250 MHz-27 500 MHz | TDD | | 37 000 MHz-40 000 MHz | TDD | | 27 500 MHz-28 350 MHz | TDD | |

# 3 Provision of compliance template for technical performance (Section 5.2.4.3 of Report ITU-R M.2411-0)

| **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** |
| **5.2.4.3.1** Peak data rate (Gbit/s) *(4.1)* | eMBB | Not applicable | Downlink | 20 |  |  |  |
| Uplink | 10 |  |  |
| **5.2.4.3.2** Peak spectral efficiency (bit/s/Hz) *(4.2)* | eMBB | Not applicable | Downlink | 30 |  |  |  |
| Uplink | 15 |  |  |
| **5.2.4.3.3** User experienced data rate (Mbit/s) *(4.3)* | eMBB | Dense Urban – eMBB | Downlink | 100 |  | Yes  No |  |
| Uplink | 50 |  | Yes  No |
| **5.2.4.3.4** 5th percentile user spectral efficiency (bit/s/Hz) *(4.4)* | eMBB | Indoor Hotspot – eMBB | Downlink | 0.3 | 0.033 (A)  0.056 (B) | Yes 🗹 No | For evaluation configuration of 4 GHz. Channel model A/B |
| Uplink | 0.21 | 0.087 (A)  0.093 (B) | Yes 🗹 No |
| Downlink | 0.3 | 0.002 | Yes 🗹 No | For evaluation configuration of 30 GHz. Channel model A/B |
| Uplink | 0.21 | 0.066 | Yes 🗹 No |
| Downlink | 0.3 | 0.001 | Yes 🗹 No | For evaluation configuration of 70 GHz. Channel model A/B |
| Uplink | 0.21 | 0.000 | Yes 🗹 No |
| eMBB | Dense Urban – eMBB | Downlink | 0.225 | 0.031 (A)  0.023 (B) | Yes 🗹 No | For evaluation configuration of 4 GHz, Channel model A/B |
| Uplink | 0.15 | 0.057 (A)  0.052 (B) | Yes 🗹 No |
| Downlink | 0.225 | 0.000 | Yes 🗹 No | For evaluation configuration of 30 GHz, Channel model A/B |
| Uplink | 0.15 | 0.000 | Yes 🗹 No |
| eMBB | Rural – eMBB | Downlink | 0.12 |  | Yes  No |  |
| Uplink | 0.045 |  | Yes  No |
|  |  |  |  |  |
|  |  |  |  |
| **5.2.4.3.5** Average spectral efficiency (bit/s/Hz/ TRxP) *(4.5)* | eMBB | Indoor Hotspot – eMBB | Downlink | 9 | 10.64 (A)  10.77 (B) | 🗹 Yes  No | For evaluation configuration of 4 GHz. Channel model A/B |
| Uplink | 6.75 | 3.20 (A)  3..29 (B) | Yes 🗹 No |
| Downlink | 9 | 7.25 | Yes 🗹 No | For evaluation configuration of 30 GHz. Channel model A/B |
| Uplink | 6.75 | 2.83 | Yes 🗹 No |
| Downlink | 9 | 6.16 | Yes 🗹 No | For evaluation configuration of 70 GHz. Channel model A/B |
| Uplink | 6.75 | 2.97 | Yes 🗹No |
| eMBB | Dense Urban – eMBB | Downlink | 7.8 | 10.25 (A)  9.97 (B) | 🗹 Yes  No | For evaluation configuration of 4 GHz, Channel model A/B |
| Uplink | 5.4 | 3.99 (A)  3.70 (B) | Yes 🗹 No |
| Downlink | 7.8 | 6.09 | Yes 🗹 No | For evaluation configuration of 30 GHz, Channel model A/B |
| Uplink | 5.4 | 2.53 | Yes 🗹 No |
| eMBB | Rural – eMBB | Downlink | 3.3 |  | Yes  No |  |
| Uplink | 1.6 |  | Yes  No |
|  |  |  |  |  |
|  |  |  |  |
| **5.2.4.3.6** Area traffic capacity (Mbit/s/m2) *(4.6)* | eMBB | Indoor-Hotspot – eMBB | Downlink | 10 |  | Yes  No |  |
| **5.2.4.3.7** User plane latency (ms) *(4.7.1)* | eMBB | Not applicable | Uplink and Downlink | 4 |  |  |  |
| URLLC | Not applicable | Uplink and Downlink | 1 |  |  |  |
| **5.2.4.3.8** Control plane latency (ms) *(4.7.2)* | eMBB | Not applicable | Not applicable | 20 |  |  |  |
| URLLC | Not applicable | Not applicable | 20 |  |  |  |
| **5.2.4.3.9** Connection density (devices/km2) *(4.8)* | mMTC | Urban Macro – mMTC | Uplink | 1 000 000 | <1,000,000 | Yes 🗹 No | For evaluation configuration A (700 MHz), 500 m ISD, Channel model A.  • 972 000 in normal mode  • 990 000 in low error mode |
| <1,000,000 | Yes 🗹 No | For evaluation configuration B (700 MHz), 1 732 m ISD, Channel model A.  • 877 000 in normal mode  • 889 000 in low error mode |
| **5.2.4.3.10** Energy efficiency *(4.9)* | eMBB | Not applicable | Not applicable | Capability to support a high sleep ratio and long sleep duration |  |  |  |
| **5.2.4.3.11** Reliability *(4.10)* | URLLC | Urban Macro –URLLC | Uplink | 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 | 84.29% | Yes 🗹 No | For evaluation configuration A (4 GHz), Channel model A. |
| Downlink | 99.72% | Yes 🗹 No | For evaluation configuration A (4 GHz), Channel model A. |
| Uplink | 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 | 83.97% | Yes 🗹 No | For evaluation configuration B (700 MHz), Channel model A. |
| Downlink | 87.63% | Yes 🗹 No | For evaluation configuration B (700 MHz), Channel model A. |
| **5.2.4.3.12** Mobility classes *(4.11)* | eMBB | Indoor Hotspot – eMBB | Uplink | Stationary, Pedestrian |  |  |  |
| eMBB | Dense Urban – eMBB | Uplink | Stationary, Pedestrian,  Vehicular (up to 30 km/h) |  |  |  |
| eMBB | Rural – eMBB | Uplink | Pedestrian, Vehicular, High speed vehicular |  |  |  |
| **5.2.4.3.13**  Mobility Traffic channel link data rates (bit/s/Hz) *(4.11)* | eMBB | Indoor Hotspot – eMBB | Uplink | 1.5 (10 km/h) |  |  |  |
|  |  |  |
| eMBB | Dense Urban – eMBB | Uplink | 1.12 (30 km/h) |  |  |  |
|  |  |  |
| eMBB | Rural – eMBB | Uplink | 0.8 (120 km/h) |  |  |  |
| 0.45 (500 km/h) |  |  |
| 0.8 (120 km/h) |  |  |  |
| 0.45 (500 km/h) |  |  |  |
| **5.2.4.3.14** Mobility interruption time (ms)  *(4.12)* | eMBB and URLLC | Not applicable | Not applicable | 0 |  |  |  |
| **5.2.4.3.15** Bandwidth and Scalability *(4.13)* | Not applicable | Not applicable | Not applicable | At least 100 MHz |  |  |  |
| Up to 1 GHz |  |  |
| Support of multiple different bandwidth values(4) |  |  |
| (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. | | | | | | | |
| Under-lined part: Evaluation results in the extended IMT-2020 evaluation process.  Strikethrough part: Evaluation results in the original Step 4 that was replaced by the updated results in the extended IMT-2020 evaluation process. | | | | | | | |

Part III

Conclusion

The followings are the evaluation summary for a RIT for IMT-2020 candidate technology in Document IMT-2020/89.

# 1 Summary the Final Evaluation Report

## 1.1 Use of information in Report ITU-R M.2412

Does Independent Evaluation Group confirm use of Report ITU-R M.2412 in their work?

🗹 Yes 🞎 No

## 1.2 Provision of compliance templates

Provision of compliance template for services (section 5.2.4.1 of Report ITU-R M.2411)

🗹 Yes 🞎 No

Provision of compliance template for technical performance (section 5.2.4.3 of Report ITU-R M.2411)

🗹 Yes 🞎 No

## 1.3 Summary of conclusions of the evaluation report

Does the Evaluation Report indicate that the candidate technology meet minimum service and spectrum requirements?

Service requirements: 🞎 Yes 🗹 No

Spectrum requirements: 🗹 Yes 🞎 No

Which test environments have been considered in the evaluation report? What is outcome of the evaluation?

|  |  |
| --- | --- |
| **Test environment** | **Does the evaluation report indicate that the minimum technical performance requirements are met in the test environment?** |
| 🞎 Indoor Hotspot – eMBB | 🞎 Yes 🗹 No |
| 🞎 Dense Urban – eMBB | 🞎 Yes🗹 No |
| 🞎 Rural – eMBB | 🞎 Yes 🞎 No |
| 🞎 Urban Macro – mMTC | 🞎 Yes 🗹 No |
| 🞎 Urban Macro – URLLC | 🞎 Yes 🗹 No |

## 1.4 Additional evaluation methodologies and assumptions

Have any additional evaluation methodologies or assumptions that had not been included in the Report ITU-R M.2412 been used in evaluation?

🞎 Yes 🗹 No

**Annex A  
  
Evaluation Results**

## A-1 Frequency bands identified for IMT

### A-1.1 450-6 000 MHz

As can be seen in Table A.1-1, the following frequency bands are supported by EUHT-5G RIT, which either contains, or part of, or overlaps certain frequency bands identified for IMT in the ITU Radio Regulations (Edition 2016).

Table A.1-1

Frequency bands of EUHT-5G RIT (in Sub-6 GHz) and IMT bands related articles in Radio Regulations

| Uplink (UL) and Downlink (DL) operating band | Duplex Mode |  | IMT related articles (notes) in Radio Regulations\* |
| --- | --- | --- | --- |
| 450-470 MHz | TDD |  | **460-890 MHz: 5.295** (470-608 MHz, or portions thereof) **5.296A** (470-698 MHz, or portions thereof, and 610-698 MHz, or portions thereof) **5.308A** (614-698 MHz) **5.313A** (698-790 MHz) **5.317A** (698-960 MHz in Region 2, 694-790 MHz in Region 1 and 790-960 MHz in Regions 1 and 3) |
| 470-698 MHz | TDD |  |
| 694/698-960 MHz | TDD |  |
| 1 427-1 518 MHz | TDD |  | **1 300-1 525 MHz: 5.341A** (1 427-1 452 MHz and 1 492-1 518 MHz in Region 1) **5.341B** (1 427-1 518 MHz in Region 2) **5.341C** (1 427-1 452 MHz and 1 492-1 518 MHz in Region 3 **5.346** (1 452-1 492 MHz) **5.346A** (1 452-1 492 MHz) |
| 1 710-2 025 MHz | TDD |  | **1 710-2 170 MHz: 5.384A** (1 710-1 885 MHz, 2 300-2 400 MHz and 2 500-2 690 MHz) **5.388** (1 885-2 025 MHz and 2 110-2 200 MHz) **5.388A** (1 885-1 980 MHz, 2 010-2 025 MHz and 2 110-2 170 MHz in Regions 1 and 3 and, 1 885-1 980 MHz and 2 110-2 160 MHz in Region 2) |
| 2 110-2 200 MHz | TDD |  |
| 2 300-2 400 MHz | TDD |  |  |
| 2 500-2 690 MHz | TDD |  |  |
| 3 300-3 400 MHz | TDD |  | **2 700-3 600 MHz: 5.429B** (3 300-3 400 MHz), **5.429D** (3 300-3 400 MHz), **5.429F** (3 300-3 400 MHz), **5.430A** (3 400-3 600 MHz), **5.431B** (3 400-3 600 MHz), **5.432A** (3 400-3 500 MHz), **5.432B** (3 400-3 500 MHz), **5.433A** (3 500-3 600 MHz) **3 600-4 800 MHz**: **5.434** (3 600-3 700 MHz) **4 800-5 250 MHz**: **5.441A** (4 800-4 900 MHz) **5.441B** (4 800-4 990 MHz) |
| 3 400-3 600 MHz | TDD |  |
| 3 600-3 700 MHz | TDD |  |  |
| 4 800-4 990 MHz | TDD |  |  |
|  |  |  | \*Excerpted from Radio Regulations Article 1 (Edition of 2016) |

## A-2 5th percentile user spectral efficiency

Simulation results of 5th percentile user spectral efficiency can be found in an Excel file in Table A-1.

## A-3 Average spectral efficiency

Simulation results of Average spectral efficiency can be found in an Excel file in Table A-1.

## A-4 Connection

Simulation results of connection can be found in an Excel file in Table A-1.

## A-5 Reliability

Simulation results of reliability can be found in an Excel file in Table A-1.

Table A-1

Simulation items and Excel files capturing the results

| **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**  **(channel mode A or B)** | **Note** | **Simulation results (in Excel files)** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Usage scenario** | **Test environment** | **Downlink or uplink** |
| **5.2.4.3.3** User experienced data rate (Mbit/s) *(4.3)* | eMBB | Dense Urban – eMBB | Downlink | 100 |  |  |  |
| Uplink | 50 |  |  |
| **5.2.4.3.4** 5th percentile user spectral efficiency (bit/s/Hz) *(4.4)* | eMBB | Indoor Hotspot – eMBB | Downlink | 0.3 | 0.033 (A)  0.056 (B) | For evaluation configuration of 4 GHz. Channel model A/B | SpectralEfficiency - 01 InH-eMBB-v01.xlsx |
| Uplink | 0.21 | 0.087 (A)  0.093 (B) |
| Downlink | 0.3 | 0.002 | For evaluation configuration of 30 GHz. Channel model |
| Uplink | 0.21 | 0.066 |
| Downlink | 0.3 | 0.001 | For evaluation configuration of 70 GHz. Channel model A/B |
| Uplink | 0.21 | 0.054 |
| eMBB | Dense Urban – eMBB | Downlink | 0.225 | 0.031 (A)  0.023 (B) | For evaluation configuration of 4 GHz, Channel model A/B | SpectralEfficiency - 02 DenseUrban-eMBB-v01.xlsx |
| Uplink | 0.15 | 0.057 (A)  0.052 (B) |
| Downlink | 0.225 | 0.000 | For evaluation configuration of 30 GHz, Channel model A/B |
| Uplink | 0.15 | 0.000 |
| eMBB | Rural – eMBB | Downlink | 0.12 |  |  |  |
| Uplink | 0.045 |  |
|  |  |  |  |
|  |  |  |
| **5.2.4.3.5** Average spectral efficiency (bit/s/Hz/ TRxP) *(4.5)* | eMBB | Indoor Hotspot – eMBB | Downlink | 9 | 10.64 (A)  10.77 (B) | For evaluation configuration of 4 GHz. Channel model A/B | SpectralEfficiency - 01 InH-eMBB-v01.xlsx |
| Uplink | 6.75 | 3.20 (A)  3.29 (B) |
| Downlink | 9 | 7.25 | For evaluation configuration of 30 GHz. Channel model A/B |
| Uplink | 6.75 | 2.83 |
| Downlink | 9 | 6.16 | For evaluation configuration of 70 GHz. Channel model A/B |
| Uplink | 6.75 | 2.97 |
| eMBB | Dense Urban – eMBB | Downlink | 7.8 | 10.25 (A)  9.97 (B) | For evaluation configuration of 4 GHz. Channel model A/B | SpectralEfficiency – 02 DenseUrban-eMBB-v01.xlsx |
| Uplink | 5.4 | 3.99 (A)  3.70 (B) |
| Downlink | 7.8 | 6.09 | For evaluation configuration of 30 GHz. Channel model A/B |
| Uplink | 5.4 | 2.53 |
| eMBB | Rural – eMBB | Downlink | 3.3 |  |  |  |
| Uplink | 1.6 |  |
|  |  |  |  |
|  |  |  |
| **5.2.4.3.6** Area traffic capacity (Mbit/s/m2) *(4.6)* | eMBB | Indoor-Hotspot – eMBB | Downlink | 10 |  |  |  |
| **5.2.4.3.9** Connection density (devices/km2) *(4.8)* | mMTC | Urban Macro – mMTC | Uplink | 1 000 000 | • 972,000 in normal mode  • 990,000 in low error mode | For evaluation configuration A (700 MHz), 500 m ISD, Channel model A. | ConnectionDensity – 03 UrbanMacro-mMTC -v01.xlsx |
| • 877,000 in normal mode  • 889,000 in low error mode | For evaluation configuration B (700 MHz), 1 732 m ISD, Channel model A. |
| **5.2.4.3.11** Reliability *(4.10)* | URLLC | Urban Macro –URLLC | Uplink | 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 | 84.29% | For evaluation configuration A (4 GHz), Channel model A. | Reliability – 04 UrbanMacro-URLLC-v01.xlsx |
| Downlink | 99.72% | For evaluation configuration A (4 GHz), Channel model A. |
| Uplink | 83.97% | For evaluation configuration B (700 MHz), Channel model A. |
|  |  | Downlink |  | 87.63% | For evaluation configuration B (700 MHz), Channel model A. |
| **5.2.4.3.13**  Mobility Traffic channel link data rates (bit/s/Hz) *(4.11)* | eMBB | Indoor Hotspot – eMBB | Uplink | 1.5 (10 km/h) |  |  |  |
|  |  |
| eMBB | Dense Urban – eMBB | Uplink | 1.12 (30 km/h) |  |  |  |
|  |  |
| eMBB | Rural – eMBB | Uplink | 0.8 (120 km/h) |  |  |  |
| 0.45 (500 km/h) |  |  |
| 0.8 (120 km/h) |  |  |
| 0.45 (500 km/h) |  |  |

Annex B  
  
Simulation assumptions and evaluation results

## B.1 eMBB\_SE

SpectralEfficiency - 01 InH-eMBB-v01.xlsx



SpectralEfficiency - 02 DenseUrban-eMBB-v01.xlsx



## B.2 mMTC\_Connection

ConnectionDensity - 03 UrbanMacro-mMTC -v01.xlsx



## B.3 URLLC\_Reliabilty

Reliability - 04 UrbanMacro-URLLC-v01.xlsx



**Annex C  
  
ARIB IEG’s response to the proponent (October 30, 2024)**



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1. \* Submitted on behalf of ARIB IMT-2020 Evaluation Group. [↑](#footnote-ref-1)