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| **Abstract:** This contribution proposes edits to the working document towards PDNR ITU-R M.[ IMT-2030.EVAL] (Annex 5.12 of Doc 5D.792) |

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| **Radiocommunication Study Groups** |  |
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| Annex 5.12 to Working Party 5D Chair’s Report |
| WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFTNEW REPORT ITU-R M.[IMT-2030.EVAL] |
| Guidelines for evaluation of radio interface technologies for IMT-2030 |

Editor’s note: this working document as a whole in square brackets for discussion.

Editor’s note: contents of Report ITU-R M.2412 are copied as starting point to facilitate the further input contributions. Input contributions are encouraged in future meetings.

Editor’s note: specific notes in square brackets with number of input contribution and the proponent are from input contributions which proposed texts for the working document, but not yet discussed.

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Editor’s note: ToC will be here when the working document is stable.

# 1 Introduction

Resolution [ITU-R 56](https://www.itu.int/pub/R-RES-R.56) defines a new term “IMT-2030” applicable to those systems, system components, and related aspects that provide far more enhanced capabilities than those described in Recommendation ITU-R M.2083.

In this regard, International Mobile Telecommunications-2030 (IMT-2030) systems are mobile systems that include the new capabilities of IMT that go beyond those of IMT-2020. Recommendation ITU-R M.2160 “Framework and overall objectives of the future development of IMT for 2030 and beyond” identifies capabilities for IMT‑2030 which would make IMT-2030 more efficient, fast, flexible, and reliable when providing diverse services in the intended usage scenarios.

# 2 Scope

Editor’s note: to further discuss “more stringent radio operating environments.”

This Report provides guidelines for the procedure, the methodology and the criteria (technical, spectrum and service) to be used in evaluating the candidate IMT-2030 radio interface technologies (RITs) or Set of RITs (SRITs) for a number of test environments. These test environments are chosen to simulate closely the more stringent radio operating environments. The evaluation procedure is designed in such a way that the overall performance of the candidate RITs/SRITs may be fairly and equally assessed on a technical basis. It ensures that the overall IMT-2030 objectives are met.

This Report provides, for proponents, developers of candidate RITs/SRITs and independent evaluation groups, the common evaluation methodology and evaluation configurations to evaluate the candidate RITs/SRITs and system aspects impacting the radio performance.

This Report allows a degree of freedom to encompass new technologies. The actual selection of the candidate RITs/SRITs for IMT-2030 is outside the scope of this Report.

The candidate RITs/SRITs will be assessed based on those evaluation guidelines. If necessary, additional evaluation methodologies may be developed by each independent evaluation group to complement the evaluation guidelines. Any such additional methodology should be shared between independent evaluation groups and sent to the Radiocommunication Bureau as information in the consideration of the evaluation results by ITU-R and for posting under additional information relevant to the independent evaluation group section of the ITU-R IMT-2030 web page. (*Editor’s note: Website URL needs to be added when it ready.*)

# 3 Structure of the Report

Section 4 provides a list of documents related to this Report.

Section 5 describes the evaluation guidelines.

Section 6 lists the criteria chosen for evaluating the RITs.

Section 7 outlines the procedures and evaluation methodology for evaluating the criteria.

Section 8 defines the tests environments for envisaged usage scenarios for evaluation; the evaluation configurations which shall be applied when evaluating IMT-2020 candidate RITs/SRITs are also given in this section.

Section 9 describes modelling approach for the evaluation.

Section 10 provides a list of acronyms and abbreviations.

# 4 Related ITU-R documents

Resolution [ITU-R 56-3](https://www.itu.int/pub/R-RES-R.56)

Resolution [ITU-R 65-1](https://www.itu.int/pub/R-RES-R.65)

Recommendation [ITU-R M.2083](https://www.itu.int/rec/R-REC-M.2083/en)

Recommendation [ITU-R M.2160](https://www.itu.int/rec/R-REC-M.2160/en)

Report [ITU-R M.2410-0](https://www.itu.int/pub/R-REP-M.2410)

Report [ITU-R M.2411-0](https://www.itu.int/pub/R-REP-M.2411)

Report [ITU-R M.2412](https://www.itu.int/pub/R-REP-M.2412)

Report [ITU-R M.2376-0](https://www.itu.int/pub/R-REP-M.2376)

Report [ITU-R M.2516](https://www.itu.int/pub/R-REP-M.2516)

Report [ITU-R M.2541](https://www.itu.int/pub/R-REP-M.2541)

Report ITU-R M.[IMT-2030.TECH PERF REQ]

Report ITU-R M.[IMT-2030.SUBMISSION]

Document [IMT-2020/1](https://www.itu.int/md/R15-IMT.2020-C-0001/en)

Document IMT-2020/2

Document IMT-2030/1

Document IMT-2030/2

# 5 Evaluation guidelines

IMT-2030 can be considered from multiple perspectives: users, manufacturers, application developers, network operators, service and content providers, and, finally, the usage scenarios – which are extensive. Therefore, candidate RITs/SRITs for IMT-2030 must be capable of being applied in a much broader variety of usage scenarios and supporting a much broader range of environments, significantly more diverse service capabilities as well as technology options. Consideration of every variation to encompass all situations is, however, not possible; nonetheless the work of the ITU-R has been to determine a representative view of IMT‑2030 consistent with the process defined in Resolution ITU-R 65-1 – Principles for the process of future development of IMT‑2020 and IMT-2030, and the key technical performance requirements defined in Report ITU‑R M.[IMT-2030. TECH PERF REQ] *–* Minimum requirements related to technical performance for IMT-2030 radio interface(s).

The parameters presented in this Report are for the purpose of consistent definition, specification, and evaluation of the candidate RITs/SRITs for IMT-2030 in ITU-R in conjunction with the development of Recommendations and Reports such as the framework, key characteristics and the detailed specifications of IMT-2030. These parameters have been chosen to be representative of a global view of IMT-2030 but are not intended to be specific to any particular implementation of an IMT-2030 technology. They should not be considered as the values that must be used in any deployment of any IMT-2030 system, nor should they be taken as the default values for any other or subsequent study in ITU or elsewhere.

Further consideration has been given in the choice of parameters to balancing the assessment of the technology with the complexity of the simulations while respecting the workload of an evaluator or a technology proponent.

This procedure deals only with evaluating radio interface aspects. It is not intended for evaluating system aspects (including those for satellite system aspects).

The following principles are to be followed when evaluating radio interface technologies for IMT‑2030:

− Evaluations of proposals can be through simulation, analytical and inspection procedures.

− The evaluation shall be performed based on the submitted technology proposals, and should follow the evaluation guidelines, using the evaluation methodology and the evaluation configurations defined in this Report.

− Evaluations through simulations contain both system-level and link-level simulations. Independent evaluation groups may use their own simulation tools for the evaluation.

− In case of evaluation through analysis, the evaluation is to be based on calculations which use the technical information provided by the proponent.

− In case of evaluation through inspection the evaluation is to be based on statements in the proposal.

The following options are foreseen for proponents and independent external evaluation groups doing the evaluations.

− Self-evaluation must be a complete evaluation (to provide a fully complete compliance template) of the technology proposal.

− An external evaluation group may perform complete or partial evaluation of one or several technology proposals to assess the compliance of the technologies with the minimum requirements of IMT-2030.

− Evaluations covering several technology proposals are encouraged.

# Overview of characteristics for evaluation

The characteristics chosen for evaluation are explained in detail in § XX of Report ITU-R M.[IMT‑2030.SUBMISSION]  including service aspect requirements, spectrum aspect requirements, and technical performance requirements, the last of which are based on Report ITU-R M.[IMT-2030.TECH PERF REQ]. These are summarized in Table XX, together with their high-level assessment method:

− Simulation (including system-level and link-level simulations, according to the principles of the simulation procedure given in § XXX below).

− Analytical (via calculation or mathematical analysis).

− Inspection (by reviewing the functionality and parameterization of the proposal).

TABLE XX

Summary of evaluation methodologies

|  |  |  |  |
| --- | --- | --- | --- |
| Characteristic for evaluation | High-level assessment method | Evaluation methodology in this Report | Related section of ReportsITU-R M.[IMT-2030.TECH PERF REQ] and ITU-R M.[IMT-2030. SUBMISSION] |
| Peak data rate | Analytical | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], § TBD |
| 5th percentile user data rate | Analytical for downlink(same as that in IMT-2020)Analytical for single band and single layer(downlink)Simulation for uplink[Simulation for multi-layer] (*Editor’s note: check test environment, layout and configuration of carrier frequency and then come back – same method of IMT-2020*) | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Peak spectral efficiency | Analytical | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], § TBD |
| Average spectral efficiency | Simulation | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| 5th percentile user spectral efficiency | Simulation | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Area traffic capacity | Analytical | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| User plane latency | Analytical | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Control plane latency | Analytical | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Connection density | Simulation | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Composite requirement | Simulation(*Editor’s Note: depending on the decision of TPR*) | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Reliability | Simulation(*Editor’s Note: this is legacy reliability same as that in IMT-2020*) | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| [5D/687 India]Coverage | [5D/687 India]Simulation,[5D/727 Japan][5D/654 Multiple, companies], [5D/659 Korea]Link budget is provided as part of the submission template | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Mobility | Simulation | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Mobility interruption time | Analytical | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Bandwidth | Inspection | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Positioning | Simulation | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], § TBD |
| [5D/637 TSDSI]Positioning latency | Inspection | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Sensing | Probabilities of detection and false alarm | Simulation | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Localization accuracy | Simulation | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Velocity | Simulation | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| [Resolution] | Analytical | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| AI related capabilities | Inspection | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Energy efficiency for sustainability | Analytical for unloaded[Simulation for loaded case] | TBD | ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| [5D/727 Japan]Extended connectivity | Inspection | TBD | Report ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Resilience | Inspection | TBD | Report ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| [Interoperability][5D/687 India]Interoperability[5D/727 Japan] proposes to delete this item | [5D/687 India]Inspection,[5D/654 Multiple companies]Submission Template | TBD | Report ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| [5D/658 Korea][Security] | [5D/654 Multiple companies], [5D/658 Korea], [5D/697 IAFI,WWRF]Submission/characteristics Template | TBD | Report ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Support of wide range of services | Inspection | TBD | Report ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| Supported spectrum band(s)/range(s) | Inspection | TBD | Report ITU-R M.[IMT-2030.TECH PERF REQ], §TBD |
| … |  |  |  |

Section 7 defines the evaluation methodology for assessing each of these criteria.

# 7 Evaluation methodology

[Editor’s note: review the document for evaluation methodology on the use of “shall”.]

The submission and evaluation process is defined in Document IMT-2030/2 *−* Submission, evaluation process and consensus building for IMT-2030*.*

The evaluation should be performed in compliance with the technical parameters provided by the proponents and the evaluation configurations specified for the test environments in § XX of this Report. Each requirement should be evaluated independently, except for the average spectral efficiency and 5th percentile user spectral efficiency – both of which criteria shall be assessed jointly using the same simulation; consequently, the candidate RITs/SRITs shall fulfil the corresponding minimum requirements jointly. Furthermore, the evaluation parameters used for the system-level simulation used in the mobility evaluation should be the same as the parameters used for system‑level simulation for average spectral efficiency and 5th percentile user spectral efficiency.

The evaluation methodology should include the following elements:

1 Candidate RITs/SRITs should be evaluated using reproducible methods including computer simulation, analytical approaches and inspection of the proposal;

2 Technical evaluation of the candidate RITs/SRITs should be made against each evaluation criterion for the required test environments;

3 Candidate RITs/SRITs should be evaluated based on technical descriptions that are submitted using a technologies description template.

In order for the ITU to be in a position to assess the evaluation results of each candidate RIT/SRIT, the following points should be taken into account:

− Use of unified methodology, software, and data sets by the evaluation groups wherever possible, e.g., in the area of channel modelling, link-level simulation, and link-to-system-level interface;

− Evaluation of multiple proposals using a single simulation tool by each evaluation group.

Evaluations of average spectral efficiency, 5th percentile user spectral efficiency, peak spectral efficiency, 5th percentile user data rate, area traffic capacity, peak data rate, mobility, reliability, and connection density, positioning, sensing related capabilities, energy efficiency, [sustainability], [5D/772 USA] [coverage] and, [AI-related capabilities] of candidate RITs/SRITs should take into account the Layer 1 and Layer 2 overhead information provided by the proponents.

India Note: Other capabilities such as security and interoperability can be added based on the discussion on these TPRs in SWG radio aspects.

## 7.1 Simulation approach

This sub-section provides detailed description of evaluation method for technical performance requirements that uses simulation.

System simulation is the simulation of the entire system which may be composed of link-level simulations and/or system-level simulations.

System-level simulation shall be based on the network layout defined in § XX of this Report. The following principles shall be followed in system-level simulation:

− Users are dropped independently with a certain distribution over the predefined area of the network layout throughout the system as described in § XX of this Report;

− UEs (User Equipment) are randomly assigned LOS and NLOS channel conditions according to the applicable channel model defined in section XX of this Report;

− Cell assignment to a UE is based on the proponent’s cell selection scheme, which must be described by the proponent;

− The applicable distances between a UE and a base station are defined in Annex 1 of this Report;

− Signal fading and interference from each transmitter into each receiver are computed on an aggregated basis;

− The interference[[1]](#footnote-1) over thermal parameter is an uplink design constraint that the proponent must take into account when designing the system such that the average interference over thermal value experienced in the evaluation is equal to or less than 10 dB;

− In simulations based on the full-buffer traffic model, packets are not blocked when they arrive into the system (i.e., queue depths are assumed to be infinite);

− UEs with a required traffic characteristics shall be modelled according to the traffic models defined in Table X in § XX of this Report;

− Packets are scheduled with an appropriate packet scheduler(s), or with non-scheduled mechanism when applicable for full buffer and other traffic models separately. Channel quality feedback delay, feedback errors, PDU (protocol data unit) errors and real channel estimation effects inclusive of channel estimation error are modelled and packets are retransmitted as necessary;

− The overhead channels (i.e., the overhead due to feedback and control channels) should be realistically modelled;

− For a given drop, the simulation is run and then the process is repeated with UEs dropped at new random locations. A sufficient number of drops is simulated to ensure convergence in the UE and system performance metrics. The proponent should provide information on the width of confidence intervals of UE and system performance metrics of corresponding mean values, and evaluation groups are encouraged to use this information;[[2]](#footnote-2)

− All cells in the system shall be simulated with dynamic channel properties and performance statistics are collected taking into account the wrap-around configuration in the network layout, noting that wrap-around is not considered in the indoor case.

In order to perform less complex system-level simulations, often the simulations are divided into separate “link-level” and “system-level” simulations with a specific link-to-system interface. Another possible way to reduce system-level simulation complexity is to employ simplified interference modelling. Such methods should be sound in principle, and it is not within the scope of this document to describe them.

Evaluation groups are allowed to use their own approaches provided that the used methodologies are:

− well described and made available to the Radiocommunication Bureau and other evaluation groups;

− included in the evaluation report.

Models for link-level and system-level simulations should include error modelling, e.g., for channel estimation, phase noise and for the errors of control channels that are required to decode the traffic channel (including the feedback channel and channel quality information). The overheads of the feedback channel and the control channel should be modelled according to the assumptions used in the overhead channels’ radio resource allocation.

### 7.1.1 Average spectral efficiency

Let R*i* (*T*) denote the number of correctly received bits by user *i* (*i* = 1, …*N*) (downlink) or from user *i* (uplink) in a system comprising a user population of *N* users and *M* Transmission Reception Points (TRxPs). Further, let W denote the channel bandwidth and *T* the time over which the data bits are received. The average spectral efficiency may be estimated by running system-level simulations over number of drops *Ndrops*. Each drop gives a value of$ \sum\_{i=1}^{N}R\_{i}(T)$ denoted as:

$R ^{\left(1\right)}\left(T\right), … R^{\left(N\_{drops}\right)} (T) $and the estimated average spectral efficiency resulting is given by:

 $\hat{SE}\_{avg}= \frac{\sum\_{j=1}^{N\_{drops}}R^{(j)} (T)}{N\_{drops} T.W.M}= \frac{\sum\_{j=1}^{N\_{drops}}\sum\_{i=1}^{N}R\_{i}^{\left(j\right)}(T)}{N\_{drops} T.W.M}$

where $\hat{SE}\_{avg}$ is the estimated average spectral efficiency and will approach the actual average with an increasing number of *Ndrops* and $R\_{i}^{\left(j\right)} (T)$ is the simulated total number of correctly received bits for user *i* in drop *j*.

The average spectral efficiency is evaluated by system level simulation using the evaluation configuration parameters of Indoor Hotspot-IC, Dense Urban-IC, Rural-IC and [Rural-UC] test environments as defined in this Report. It should be noted that the average spectral efficiency is evaluated only using a single-layer layout configuration even if a test environment comprises a multi-layer layout configuration.

The results from the system-level simulation are used to derive the average spectral efficiency as defined in Report ITU-R M.[IMT-2030.TECH PERF REQ]. The necessary information is the number of correctly received bits per UE during the active session time the UE is in the simulation. The effective bandwidth is the operating bandwidth normalized appropriately considering the uplink/downlink ratio for TDD system.

Layer 1 and Layer 2 overheads should be accounted for in time and frequency. Examples of Layer 1 overhead include synchronization, guard band and DC subcarriers, guard/switching time (for example, in TDD systems), pilots and cyclic prefix. Examples of Layer 2 overhead include common control channels, HARQ ACK/NACK signalling, channel feedback, random access, packet headers and CRC. It must be noted that in computing the overheads, the fraction of the available physical resources used to model control overhead in Layer 1 and Layer 2 should be accounted for in a non-overlapping way. Power allocation/boosting should also be accounted for in modelling resource allocation for control channels.

### 7.1.2 5th percentile user spectral efficiency

5th percentile user spectral efficiency is the 5th percentile point of the cumulative distribution function (CDF) of the normalized user throughput, estimated from all possible user locations.

Let user *i* in drop *j* correctly decode $R\_{i}^{\left(j\right)} (T)$ accumulated bits in [0, *T*]. For non-scheduled duration of user *i* zero bits are accumulated. During this total time user *i* receives accumulated service time of *Ti*≤ *T*, where the service time is the time duration between the first packet arrival and when the last packet of the burst is correctly decoded. In case of full buffer, *Ti* = *T*. Hence the rate normalised by service time *Ti*and channel bandwidth W of user *i* in drop *j*, $r\_{i}^{(j)}$, is:

 $r\_{i}^{(j)}$= $\frac{R\_{i}^{\left(j\right)} (T)}{T\_{i}.W}$

Running *Ndrops*simulations leads to *Ndrops*×*N* values of $r\_{i}^{(j)}$ of which the lowest 5th percentile point of the CDF is used to estimate the 5th percentile user spectral efficiency.

The 5th percentile user spectral efficiency is evaluated by system level simulation using the evaluation configuration parameters of Indoor Hotspot-IC, Dense Urban-IC, Rural-IC and [Rural-UC] test environments. It should be noted that the 5th percentile user spectral efficiency is evaluated only using a single-layer layout configuration even if a test environment comprises a multi-layer layout configuration. The 5th percentile user spectral efficiency shall be evaluated using identical simulation assumptions as the average spectral efficiency for that test environment.

The results from the system-level simulation are used to derive the 5th percentile user spectral efficiency as defined in Report ITU-R M.[IMT-2030.TECH PERF REQ]. The necessary information is the number of correctly received bits per UE during the active session time the UE is in the simulation. The effective bandwidth is the operating bandwidth normalized appropriately considering the uplink/downlink ratio for TDD system.

Layer 1 and Layer 2 overheads should be accounted for in time and frequency. Examples of Layer 1 and Layer 2 overheads can be found in § XX for average spectral efficiency.

### 7.1.3 Connection density

Report ITU-R M.2412

There are two possible evaluation methods to evaluate connection density requirement defined in ITU-R M.[IMT-2030.TECH PERF REQ]:

− non-full buffer system-level simulation;

− full-buffer system-level simulation followed by link-level simulation.

The following steps are used to evaluate the connection density based on non-full buffer system-level simulation. Traffic model used in this method is defined in Table X in § XX of this Report.

*Step 1:* Set system user number per TRxP as *N.*

*Step 2:* Generate the user packet according to the traffic model.

*Step 3:* Run non-full buffer system-level simulation to obtain the packet outage rate. The outage rate is defined as the ratio of the number of packets that failed to be delivered to the destination receiver within a transmission delay of less than or equal to 10s to the total number of packets generated in *Step 2*.

*Step 4:* Change the value of *N* and repeat *Step 2-3* to obtain the system user number per TRxP *N’* satisfying the packet outage rate of 1%.

*Step 5:* Calculate connection density by equation *C* = *N’ / A*, where the TRxP area *A* is calculated as *A* = ISD2 × sqrt(3)/6, and ISD is the inter-site distance.

The requirement is fulfilled if the connection density *C* is greater than or equal to the connection density requirement defined in Report ITU-R M.[IMT-2030.TECH PERF REQ].

The simulation bandwidth used to fulfil the requirement should be reported. Additionally, it is encouraged to report the connection efficiency (measured as *N’* divided bysimulation bandwidth) for the achieved connection density.

The following steps are used to evaluate the connection density based on full-buffer system-level simulation followed by link-level simulation. Traffic model used in this method is defined in Table X in § XX of this Report.

*Step 1:* Perform full-buffer system-level simulation using the evaluation parameters for Urban Macro - MC test environments, determine the uplink *SINR*i for each percentile *i*=1…99 of the distribution over users, and record the average allocated user bandwidth *W*user.

– In case UE multiplexing on the same time/frequency resource is modelled in this step, record the average number of multiplexed users *Nmux*. *Nmux* = 1 for no UE multiplexing.

*Step 2:* Perform link-level simulation and determine the achievable user data rate *Ri* for the recoded *SINRi* and *W*uservalues.

– In case UE multiplexing on the same time/frequency resource is modelled in this step, record the average number of multiplexed users *nmux,i* under *SINRi* . The achievable data rate for this case is derived by *Ri = Zi/nmux,i*, where aggregated bit rate *Zi* is the summed bit rate of *nmux,i* users on *W*user. *nmux,i* = 1 for no UE multiplexing.

*Step 3:* Calculate the packet transmission delay of a user as *D*i = *S*/*R*i, where *S* is the packet size.

*Step 4:* Calculate the traffic generated per user as *T* = *S*/*T*inter-arrival, where *T*inter-arrival is the inter‑packet arrival time.

*Step 5:* Calculate the long-term frequency resource requested under *SINRi* as *B*i = *T*/(*R*i/*W*user).

*Step 6:* Calculate the number of supported connections per TRxP, *N* = *W* / mean(*B*i). *W* is the simulation bandwidth. The mean of *B*i may be taken over the best 99% of the *SINRi* conditions.

– In case UE multiplexing is modelled in *Step 1*, *N* = *N*mux × *W* / mean(*B*i). In case UE multiplexing is modelled in *Step 2*, *N* = *W* / mean(*B*i/*nmux,i*).

 *Step 7:* Calculate the connection density as *C* = *N* / *A*, where the TRxP area *A* is calculated as *A* = ISD2 × sqrt(3)/6, and ISD is the inter-site distance.

The requirement is fulfilled if the 99th percentile of the delay per user *D*i is less than or equal to 10s, and the connection density is greater than or equal to the connection density requirement defined in Report ITU-R M.[IMT-2030.TECH PERF REQ].

The simulation bandwidth used to fulfil the requirement should be reported. Additionally, it is encouraged to report the connection efficiency (measured as *N* divided bysimulation bandwidth) for the achieved connection density.

### 7.1.4 Mobility

[5D/460 CHN]

Mobility shall be evaluated under [5D/460 CHN]Indoor Hotspot-IC, Dense Urban-IC, [5D/687 India] Rural-IC and Rural-UC test environment using the same evaluation parameters and configuration selected for the evaluation of average spectral efficiency and 5th percentile user spectral efficiency. Under [Rural-IC] test environment, target values for both mobility of [120 km/h and 500 km/h] in Table X of Report ITU-R M.[IMT-2030.TECH PERF REQ]. shall be achieved to fulfil mobility requirements of Rural-IC test environment.

The evaluator shall perform the following steps in order to evaluate the mobility requirement.

*Step 1:* Run uplink system-level simulations, identical to those for average spectral efficiency, and 5th percentile user spectral efficiency except for speeds taken from Table X of Report ITU-R M.[IMT-2030.TECH PERF REQ], using link-level simulations and a link-to-system interface appropriate for these speed values, for the set of selected test environment(s) associated with the candidate RITs/SRITs and collect overall statistics for uplink *SINR* values, and construct CDF over these values for each test environment.

*Step 2:* Use the CDF for the test environment(s) to save the respective 50th-percentile *SINR* value.

*Step 3:* Run new uplink link-level simulations for the selected test environment(s) for either NLOS or LOS channel conditions using the associated speeds in Table X of Report ITU‑R M.[IMT-2030.TECH PERF REQ], as input parameters, to obtain link data rate and residual packet error ratio as a function of *SINR*. The link-level simulation shall use air interface configuration(s) supported by the proposal and take into account retransmission, channel estimation and phase noise impact.

*Step 4:* Compare the uplink spectral efficiency values (link data rate normalized by channel bandwidth) obtained from *Step 3* using the associated *SINR* value obtained from *Step 2* for selected test environments, with the corresponding threshold values in the Table X of Report ITU-R M.[IMT-2030.TECH PERF REQ].

*Step 5:* The proposal fulfils the mobility requirement if the spectral efficiency value is larger than or equal to the corresponding threshold value and if also the residual decoded packet error ratio is less than 1%, for all selected test environments. For the selected test environment, it is sufficient if one of the spectral efficiency values (using either NLOS or LOS channel conditions) fulfils the threshold.

Similar methodology can be used for downlink in case this is additionally evaluated.

### 7.1.5 Reliability

The evaluator shall perform the following steps in order to evaluate the reliability requirement using system-level simulation followed by link-level simulations.

*Step 1:* Run downlink or uplink full buffer system-level simulations of candidate RITs/SRITs using the evaluation parameters of Urban macro-HRLLC test environment see § XX below, and collect overall statistics for downlink or uplink *SINR* values, and construct CDF over these values.

*Step 2:* Use the CDF for the Urban macro-HRLLC test environment to save the respective 5th percentile downlink or uplink *SINR* value.

*Step 3:* Run corresponding link-level simulations for either NLOS or LOS channel conditions using the associated parameters in the Table X of this Report, to obtain success probability, which equals to (1-*Pe*), where *Pe* is the residual packet error ratio within maximum delay time as a function of *SINR* taking into account retransmission.

*Step 4:* The proposal fulfils the reliability requirement if at the 5th percentile downlink or uplink *SINR* value of *Step 2* and within the required delay, the success probability derived in *Step 3* is larger than or equal to the required success probability. It is sufficient to fulfil the requirement in either downlink or uplink, using either NLOS or LOS channel conditions.

### 7.1.6 Energy efficiency for sustainability (if quantitative metric is defined and simulation is needed)

[5D/721 CHN]

• Network energy efficiency

For loaded case(s), the evaluator should perform the following steps in order to evaluate the network energy efficiency for the candidate RIT/SRIT.

*Step 0:* Calculate network energy consumption of the reference case as defined in Report ITU-R M.[IMT-2030.TECH PERF REQ]. Proponents are encouraged to use power model defined in Annex x. Justification is needed in case of modified or new power model.

*Step 1:* Set system user number per TRxP as *N.*

*Step 2:* Generate the user packet according to the traffic model defined in section 8.4.

*Step 3:* Change the value of *N* and repeat *Step 1-2* until network load reached the condition of at least [x%-loaded].

*Step 4:* Run system level simulation to calculate network energy consumption of at least [x%-loaded] conditions with the energy saving technologies supported by RIT/SRIT. The same power model as *Step 0* should be used. Impacts on communication performance associated with the evaluated energy saving technologies should be reported.

*Step 5:* The proposal fulfils the energy efficiency requirement if the relative energy saving between the energy consumption of at least [x%-loaded] in *Step 4* and the reference case is not less than the energy efficiency requirement defined in Report ITU-R M.[IMT‑2030.TECH PERF REQ].

• Device energy efficiency

For loaded case(s), the evaluator should perform the following steps in order to evaluate the device energy efficiency for the candidate RIT/SRIT.

*Step 1:* Calculate device energy consumption of the reference case as defined in Report ITU-R M.[IMT-2030.TECH PERF REQ]. Proponents are encouraged to use power model defined in Annex x. Justification is needed in case of modified or new power model.

*Step 2:* Run simulation to generate the user packet according to the traffic model defined in section 8.4 for [x%-loaded] condition.

*Step 3:* Simulatedevice energy consumption of [x%-loaded] conditions with the energy saving technologies supported by RIT/SRIT. The same power model as *Step 1* should be used. Impacts on communication performance associated with the evaluated energy saving technologies should be reported.

*Step 4:* The proposal fulfils the energy efficiency requirement if the relative energy saving between the energy consumption of [x%-loaded] in *Step 3* and the reference case in *Step 1* is not less than the energy efficiency requirement defined in Report ITU-R M.[IMT-2030.TECH PERF REQ]

[5D/687 India] to delete energy efficiency from “simulation” session

### 7.1.7 Positioning

Positioning shall be evaluated by system-level simulation for Indoor Factory-ISAC and Urban Macro-ISAC/Urban-ISAC test environment(s) using the parameters in Tables X in § 8.4.

Editor’s Note: Regarding positioning and sensing evaluation, Test Environment configurations could be different.

The evaluator shall perform the following steps for each test environment.

*Step 1:* Perform simulation of candidate RITs/SRITs using the evaluation parameters of Indoor Factory-ISAC and Urban Macro-ISAC/Urban-ISAC test environments. Location of the BSs in the test environment is according to the network layout. UEs are dropped randomly and uniformly in the test environment deployment. For indoor deployment, UEs outside of the convex hull of the deployment are excluded from the evaluation. Generate the links between UE and the corresponding BSs according to the evaluation parameters in section 8.4.

*Step 2:* Estimate the positioning-related measurement(s) for the link(s) between each UE and the corresponding BS(s). Calculate the UE location based on the combination of positioning-related measurement(s) from corresponding BS(s) and/or the UE. Compare the calculated UE location with the UE’s real location to assess the positioning errors (horizontal and [vertical]).

*Step 3:* Evaluate positioning errors over multiple UE drops by repeating *Step 1* & *2*. Plot the CDF curves of the positioning errors. The 90th percentile point of positioning errors CDF curve is the positioning accuracy.

Editor’s Note: keep alignment of the following part as a final step or a paragraph among all evaluation methodologies.

The positioning requirement is fulfilled if the positioning accuracy values are better than or equal to the target positioning accuracy requirements for the simulated test environment as defined in Report ITU-R M.[IMT-2030.TECH PERF REQ].

### 7.1.8 Sensing-related requirements

The following Sensing-related capabilities shall be evaluated under Urban Macro-ISAC /Urban-ISAC and Indoor Factory-ISAC.

#### 7.1.8.1 Detection probability and false alarm probability

The evaluator shall perform the following steps in order to evaluate the detection probability and false alarm probability requirement using system-level simulations, over a number of simulation drops.

*Step 1:* For each simulation drop, [with sensing nodes (TRxPs and/or UEs) according to their layout and sensing mode(e.g., mono-static, bi-static),] scatter the sensing objects according to sensing object distribution, [then generate the links between the sensing object and the sensing node(s) according to the evaluation parameters in section 8.4].

*Step 2:* For each simulation drop, generate sensing signal for Tx sensing node, and obtain received sensing signal at Rx sensing node. Perform sensing signal processing, and determine whether a sensing object is present or not.

*Step 3:* Run multiple drops by repeating *Steps 1-2*. Collect statistics for the number of correct detection of the sensing object (ND), and the number of false detection of the sensing object (NFA).

*Step 4:* Calculate the probabilities of detection (PD) and false alarm (PFA), considering all the sensing objects over the simulation drops.

The requirement is fulfilled if the detection probability and false alarm probability are better than or equal to the detection probability and false alarm probability requirement defined in Report ITU-R M.[IMT-2030.TECH PERF REQ].

#### 7.1.8.2 Localization accuracy

The evaluator shall perform the following steps in order to evaluate the localization accuracy requirement using system-level simulations, over a number of simulation drops.

*Step 1:* For each simulation drop, [with sensing nodes (TRxPs and/or UEs) according to their layout and sensing mode (e.g., mono-static, bi-static)] scatter the sensing objects according to sensing object distribution, [then generate the links between the sensing object and the sensing node(s) according to the evaluation parameters in section 8.4].

*Step 2:* For each simulation drop, generate sensing signal from Tx sensing node, and obtain received sensing signal at Rx sensing node. Perform sensing signal processing, [detect and] calculate the location of the sensing object(s). Compare the calculated sensing object location with the sensing object’s actual location, to calculate the horizontal/vertical localization error .

*Step 3:* Run multiple simulation drops by repeating *Steps 1-2* and plot the CDF curves of the horizontal/vertical localization errors. The [90/95]th-percentile point of horizontal/ vertical localization errors CDF curves is the horizontal/vertical localization accuracy.

The requirement is fulfilled if the horizontal/vertical localization accuracy values are better than or equal to the horizontal/vertical localization accuracy requirements defined in Report ITU-R M.[IMT-2030.TECH PERF REQ].

#### 7.1.8.3 Velocity accuracy

The evaluator shall perform the following steps in order to evaluate the velocity accuracy requirement using system-level simulations, over a number of simulation drops.

*Step 1:* For each simulation drop, [with sensing nodes (TRxPs and/or UEs) according to their layout and sensing mode (e.g., mono-static, bi-static)] scatter the sensing objects according to sensing object distribution, [then generate the links between the sensing object and the sensing node(s) according to the evaluation parameters in section 8.4].

*Step 2:* For each simulation drop, generate sensing signal from Tx sensing node, and obtain received sensing signal at Rx sensing node. Perform sensing signal processing, [detect and] obtain the velocity of the sensing object(s). Compare the obtained sensing object velocity with the sensing object’s actual velocity, to calculate the velocity estimation error. [*Editor’s note: review “velocity” after more detailed discussion.*]

*Step 3:* Run multiple simulation drops by repeating *Steps 1-2* and plot the CDF curves of the velocity errors. The [90/95]th-percentile point of velocity estimation errors CDF curves is the velocity accuracy.

The requirement is fulfilled if the velocity accuracy values are better than or equal to the velocity accuracy requirements defined in Report ITU-R M.[IMT-2030.TECH PERF REQ].

### 7.1.9 Composite requirement

Editor’s Note: depending on the decision of TPR.

There [are two possible] evaluation methods to evaluate composite requirement defined in Report ITU-R [IMT-2030.TECH PERF REQ]:

− non-full buffer system-level simulation;

− [full-buffer system-level simulation followed by link-level simulation.]

The following steps are used to evaluate the composite requirement based on non-full buffer system-level simulation. The traffic model used in this method is defined in [Table 8-X in § 8.4] of this Report.

*Step 1:* Set system user number per TRxP as *N.*

*Step 2:* Generate the user packet according to the traffic model(s) defined in [Table 8-X in § 8.4] of this Report.

*Step 3:* Run non-full buffer system-level simulation to obtain the user satisfaction rate. The user satisfaction rate is defined as the ratio of the number of satisfied users to the total number of users. A satisfied user is defined as a user achieving the required packet outage rate. The packet outage rate is defined as the ratio of the number of packets that failed to be delivered to the destination receiver within a required latency to the total number of packets generated for this user in *Step 2*.

*Step 4:* Change the value of *N* and repeat *Step 2-3* to obtain the system user number per TRxP *N’* satisfying user satisfaction rate of at least [90/95]%.

*[Step 5:* Calculate [number of users] by equation *C* = *N’ / A* where the TRxP area *A* is calculated as *A* = ISD2 × sqrt(3)/6, and ISD is the inter-site distance.]

[The requirement is fulfilled if the [composite requirement C] is greater than or equal to the composite requirement defined in Report ITU-R M.[IMT-2030.TECH PERF REQ].]

[The simulation bandwidth used to fulfil the requirement [should be reported / is defined in § 8.4 of this Report]. [Additionally, it is encouraged to report the connection efficiency (measured as *N’* divided by simulation bandwidth) for the achieved composite requirement.]]

[5D/687 India]

### 7.1.10 Coverage

Coverage should be evaluated based on the configurations given for Rural-UC test environment as per section 8.4.X.

*Step 1:* Run link level simulation for downlink and uplink data channels with the given configuration.

*Step 2:* Evaluate the MCL for the downlink and uplink using link budget.

*Step 3:* Evaluate the corresponding distance for LOS and NLOS, for the associated channel model, for this test environment.

*Step 4:* Report whether this distance exceeds the minimum coverage requirement as specified in TPR.

### 7.1.11 5th percentile user data rate

5th percentile user data rate is the 5th percentile point of the cumulative distribution function (CDF) of the normalized user throughput, estimated from all possible user locations. Simulation is performed for 5th percentile user data rate only in uplink case.

For uplink, let user *i* in drop *j* correctly decode $R\_{i}^{\left(j\right)}(T)$ accumulated bits in [0, *T*]. For non-scheduled duration of user *i* zero bits are accumulated. The rate normalised by T of user *i* in drop *j*, $r\_{i}^{(j)}$, is:

 $r\_{i}^{(j)}$= $\frac{R\_{i}^{\left(j\right)} (T)}{T\_{}}$

Run *Ndrops*simulations, and *Ndrops*×*N* values of $r\_{i}^{(j)}$are used to estimate the CDF. The lowest 5th percentile point of the CDF is used to estimate the 5th percentile user data rate.

The 5th percentile user data rate is evaluated by system level simulation using the evaluation configuration parameters of Dense Urban-IC [and Rural-UC] test environment[s]. The 5th percentile user data rate shall be evaluated using identical simulation assumptions as the 5th percentile user spectral efficiency for that test environment, except the bandwidth. Proponents should report the bandwidth used in the simulation.

[In case of multi-layer configuration, system-level simulation is used. In this case, the single user data rate may be aggregated over layers and/or bands. The 5th percentile user data rate is derived from the 5th percentile point of the CDF of single user data rate.]

Layer 1 and Layer 2 overheads should be accounted for in time and frequency. Examples of Layer 1 and Layer 2 overheads can be found in § XX for average spectral efficiency.

## 7.2 Analytical approach

For §§ XX to XX below, a straightforward calculation based on the definition in Report ITU‑R M.[IMT-2030.TECH PERF REQ] will be sufficient to evaluate the relevant technical performance requirements. The evaluation shall describe how this calculation has been performed. Evaluation groups should follow the calculation provided by proponents if it is justified properly.

### 7.2.1 Peak spectral efficiency calculation

The peak spectral efficiency is calculated as specified in § XX of Report ITU‑R M.[IMT-2030.TECH PERF REQ]. The proponent should report the assumed frequency band(s) of operation and channel bandwidth, for which the peak spectral efficiency value is achievable. For TDD, the channel bandwidth information should include the effective bandwidth, which is the operating bandwidth normalized appropriately considering the uplink/downlink ratio.

The antenna configuration to be used for peak spectral efficiency is defined in Table X of this Report. Layer 1 and Layer 2 overhead should be accounted for in time and frequency, in the same way as assumed for the “Average spectral efficiency”.

[5D/460 CHN]

Proponents should demonstrate that the peak spectral efficiency requirement can be met for, at least, one of the carrier frequencies assumed in the test environments under the IC usage scenario.

### 7.2.2 Peak data rate calculation

The peak data rate is calculated as specified in § XX of Report ITU-R M.[IMT-2030.TECH PERF REQ], using peak spectral efficiency and maximum assignable channel bandwidth.

Peak spectral efficiency and maximum assignable channel bandwidth may have different values in different frequency bands. The peak data rate may be summed over multiple bands in case of bandwidth aggregated across multiple bands.

The proponent should report the peak data rate value achievable by the candidate RITs/SRITs and identify the assumed frequency band(s) of operation, the maximum assignable channel bandwidth in that band(s) and the main assumptions related to the peak spectral efficiency over the assumed frequency band(s) (e.g., antenna configuration).

[5D/460 CHN]

Proponents should demonstrate that the peak data rate requirement can be met for, at least, one carrier frequency or a set of aggregated carrier frequencies (where it is the case), assumed in the test environments under the IC usage scenario

### 7.2.3 5th percentile user data rate

The evaluation is conducted in Dense Urban-IC [and Rural-UC] test environment[s]. Analytical approach is adopted for 5th percentile user data rate only in the downlink.

For downlink with one frequency band and one TRxP layer, 5th percentile user data rate is derived analytically from the 5th percentile user spectral efficiency according to equation (3) defined in Report ITU-R M.[IMT-2030.TECH PERF REQ]. The bandwidth used should be reported by the proponent.

[In case of multi-layer configuration, system-level simulation is used. In this case, the single user data rate may be aggregated over layers and/or bands. The 5th percentile user data rate is derived from the 5th percentile point of the CDF of single user data rate.]

### 7.2.4 Area traffic capacity calculation

The evaluation is conducted in Indoor Hotspot-IC [5D/727 Japan] and Dense Urban -IC test environment where a single band is considered.

Area traffic capacity is derived based on the achievable average spectral efficiency, TRxP density and bandwidth.

Let W denote the channel bandwidth and$ ρ$ the TRxP density (TRxP/m2). The area traffic capacity *Carea* is related to average spectral efficiency *SEavg* as follows:

 *Carea* = ρ × *W* × *SEavg*

### 7.2.5 Control plane latency calculation

The proponent should provide the elements and their values in the calculation of the control plane latency. Table X provides an example of the elements in the calculation of the control plane latency.

TABLE x

Example of control plane latency analysis template

|  |  |  |
| --- | --- | --- |
| Step | Description | Value |
| 1 | Random access procedure |  |
| 2 | UL synchronization |  |
| 3 | Connection establishment + HARQ retransmission |  |
| 4 | Data bearer establishment + HARQ retransmission |  |
|  | Total control plane latency |  |

### 7.2.6 User plane latency calculation

The proponent should provide the elements and their values in the calculation of the user plane latency, for both UL and DL. Table X provides an example of the elements in the calculation of the user plane latency.

TABLE x

Example of user plane latency analysis template

| Step | Description | Value |
| --- | --- | --- |
| 1 | UE processing delay |  |
| 2 | Frame alignment |  |
| 3 | TTI for data packet transmission |  |
| 4 | HARQ retransmission |  |
| 5 | BS processing delay |  |
|  | Total one-way user plane latency |  |

### 7.2.7 Mobility interruption time calculation

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

### 7.2.8 Energy efficiency for sustainability

For unloaded case as defined in ITU-R M.[IMT-2030.TECH PERF REQ], the evaluator should perform the following steps in order to evaluate the energy efficiency for the candidate RIT/SRIT for UE and network:

*Step 1:* Calculate energy consumption of the reference fully loaded case defined in Report ITU-R M.[IMT-2030.TECH PERF REQ]. Power model used to calculate energy consumption should be reported. This calculation includes energy used in active, sleep, and transition states to determine the total required energy.

*Step 2:* Calculate energy consumption of unloaded case over a time duration with the energy saving technologies supported by RIT/SRIT. The same power model as *Step 1* should be used. Impacts on communication performance associated with the evaluated energy saving technologies should be reported.

*Step 3:* The proposal fulfils the energy efficiency requirement [if ratio/the relative energy saving (in percentage) between the energy consumption of unloaded condition in *Step 2* and the reference fully loaded case in *Step 1* is [not] less than the energy efficiency requirement]/[calculated power consumption is as small as possible] defined in Report ITU-R M.[IMT-2030.TECH PERF REQ]

Editor’s note: Example power models, defined by 3GPP, can be found in TR 38.864 (BS Category 2) for base station and TR 38.840 for UE power model.

[5D/721 CHN], [5D/781 Ericsson]

The simulation bandwidth used to fulfil the requirement should be reported /is defined in § 8.4 of this Report. Additionally, it is encouraged to report the connection efficiency (measured as *N’* divided by simulation bandwidth) for the achieved connection density.

The following steps are used to evaluate the composite requirement based on full-buffer system-level simulation followed by link-level simulations. The traffic model used in this method is defined in Table 8-x in § 8.4 of this Report.

The evaluator shall perform the following steps in order to evaluate the composite requirement using system-level simulation followed by link-level simulations.

*Step 1:* Run downlink or uplink full buffer system-level simulations of candidate RITs/SRITs using the evaluation parameters of [XXX] test environment see [§ XX] below, determine the *SINR*i for each percentile *i*=1…99 of the distribution over users. Also store the bandwidth *W*user allocated to users.

*Step 2:* Use the CDF for the [XXX] test environment to save the respective 5th percentile downlink or uplink *SINR* value.

*Step 3:* Run link-level simulations to obtain the cumulative distribution of delay *F(d)* = *P(D<=d)* for sending a packet of size *S*, using the bandwidth *W*user at the 5th percentile SINR. The application packet size *S* is determined based on the required bitrate (*R*b,req) and an associated frame rate (*R*f), which needs to accompany the requirement, as *S* = *R*b,req/*R*f. For non-periodic services the application packet size is given directly. The link simulator needs to model relevant capabilities of the RIT for fulfilling the requirement, e.g., segmentation, link adaptation, retransmission protocols, TDD patterns, and processing delays.

*Step 4:* The proposal fulfils (the first part of the) the composite requirement if the probability of the delay being lower than or equal to the delay requirement is larger than the reliability requirement (*p*req), i.e., *F(d*req*)* >= *p*req. Equivalently, if the delay measured at a percentile of the distribution corresponding to the reliability requirement, *F*-1(*p*req) is lower than or equal to the delay requirement, the requirement is fulfilled.

*Step 5:* (This can be done together with *Step 3*) Perform link-level simulation and determine the achievable user data rate *Ri* for the recoded *SINRi* and *W*user values.

*Step 6:* Calculate the traffic generated per user as *T* = *S*/*T*inter-arrival, where *T*inter-arrival is the inter-packet arrival time.

*Step 7:* Calculate the long-term frequency resource requested under *SINRi* as *B*i = *T*/(*R*i/*W*user).

*Step 8:* Calculate the number of supported connections per TRxP, *N* = *W* / mean(*B*i). *W* is the simulation bandwidth. The mean of *B*i may be taken over the best 99% of the *SINRi* conditions.

*Step 9:* The proposal fulfils (the second part of the requirement) the requirement if *N* >= *N*req, where *N*req is the required number of connections.

[5D/684 Apple], [5D/721 CHN]

### 7.2.9 Sensing resolution

Sensing Resolution is calculated as specified in Report ITU-R M.[IMT-2030.TECH PERF REQ]/defined as the minimum difference of the measured value (e.g., range, localization) of two target objects, in order to distinguish these two target objects. The proponents should report the assumed channel bandwidth.

Let B denotes the bandwidth and$ c$ the speed of light, $β$ is the bistatic angle between the incident ray and scattering ray. The range resolution $Δr$can be calculated by:

For monostatic sensing,

 $Δr=c/2B$

For bistatic sensing,

 $Δr=\frac{c}{2B \cos(\frac{β}{2})}$

Proponents should demonstrate that the sensing resolution requirement can be met for, at least, one of the carrier frequencies assumed in the test environments under an ISAC usage scenario.

[5D/687 India]

### 7.2.9 Sensing resolution

[TBD]

## 7.3 Inspection approach

Inspection is conducted by reviewing the functionality and parameterization of a proposal.

### 7.3.1 Bandwidth

The support of maximum bandwidth required in section 4.11 of Report ITU-R M.[IMT-2030.TECH PERF REQ], is verified by inspection of the proposal.

The scalability requirement is verified by demonstrating that the candidate RITs/SRITs can support multiple different bandwidth values. These values shall include the minimum and maximum supported bandwidth values of the candidate RITs/SRITs.

The requirements for bandwidth or the bandwidth numbers demonstrated by the proponent do not pose any requirements or limitations for other Technical Performance Requirements that depend on bandwidth. If any other requirement requires a higher bandwidth, the capability to reach that bandwidth should be described as well.

### 7.3.2 Resilience

Resilience is verified by inspecting whether the candidate RITs/SRITs can support functionalities as defined in Report ITU-R M.[IMT-2030.TECH PERF REQ].

### 7.3.3 AI-related capabilities

The AI-related capabilities are verified by inspection of the proposal by demonstrating that the candidate RITs/SRITs can support the AI-related capabilities, as defined in § X.XX of Report ITU-R M.[IMT-2030.TECH PERF REQ].

### [5D/727 Japan]

### 7.3.x Extended Connectivity

The Extended Connectivity required in § 4.X of Report ITU-R M.[IMT-2030.TECH PERF REQ], is verified by inspection of the proposal.

[5D/637 TSDSI]

### 7.3.x Positioning latency

The positioning latency required in § 4.11 of Report ITU-R M.[IMT-2030.TECH PERF REQ], is verified by inspection.

### 7.3.x Sensing Latency

The sensing latency required in § 4.13 of Report ITU-R M.[IMT-2030.TECH PERF REQ], is verified by inspection.

### 7.3.x Support of wide range of services

There are elements of the minimum technical performance requirements identified within Report ITU-R M.[IMT-2030.TECH PERF REQ that indicate whether or not the candidate RITs/SRITs are capable of enabling certain services and performance targets, as envisioned in Recommendation ITU-R M.2160.

The support of a wide range of services is verified by inspection of the candidate RITs/SRITs ability to meet the minimum technical performance requirements for various usage scenarios and their associated test environments.

### 7.3.x Supported spectrum band(s)/range(s)

The spectrum band(s) and/or range(s) that the candidate RITs/SRITs can utilize is verified by inspection.

# 8 Test environments and evaluation configurations

This section describes the test environments and the related evaluation configurations (including simulation parameters) necessary to evaluate the performance criteria of candidate RITs/SRITs (details of test environments and channel models can be found in section XX of this Report).

These predefined test environments are used in order to evaluate the requirements for the technology proposals. IMT-2030 is to cover a wide range of performance in a wide range of environments. Although it should be noted that thorough testing and evaluation is prohibitive, these test environments have therefore been chosen such that typical and different deployments are modelled and critical aspects in system design and performance can be investigated. Focus is thus on scenarios testing limits of performance.

## 8.1 Usage scenarios

As defined in Recommendation ITU-R M.2160, IMT-2030 is envisaged to expand and support diverse usage scenarios and applications that will continue beyond IMT-2020. There are six usage scenarios for IMT-2030 as follows:

– **Immersive communication**: This usage scenario extends the enhanced Mobile Broadband (eMBB) of IMT-2020 and covers use cases which provide a rich and interactive video (immersive) experience to users, including the interactions with machine interfaces.

 This usage scenario covers a range of environments, including hotspots, urban and rural, which arise with additional and new requirements compared with those of eMBB from IMT-2020.

 Typical use cases include communication for immersive XR, remote multi-sensory telepresence, and holographic communications. Supporting mixed traffic of video, audio, and other environment data in a time-synchronized manner is an integral part of immersive communications, including also stand-alone support of voice.

 Capabilities that aim for enhanced spectrum efficiency and consistent service experiences along with leveraging the balance between higher data rates and increased mobility in various environments are essential. Certain immersive communication use cases may also require support of high reliability and low latency for responsive and accurate interaction with real and virtual objects, as well as larger system capacity for simultaneously connecting numerous devices.

– **Hyper reliable and low-latency communication**: This usage scenario extends the Ultra-Reliable and Low-Latency Communication (URLLC) of IMT‑2020 and covers specialized use cases that are expected to have more stringent requirements on reliability and latency. This is typically for time-synchronized operations, where failure to meet these requirements could lead to severe consequences for the applications.

 Typical use cases include communications in an industrial environment for full automation, control and operation. These types of communications can help in realizing various applications such as machine interactions, emergency services, tele-medicine, and monitoring for electrical power transmission and distribution.

 This usage scenario would require support of enhanced reliability and low latency, and depending on the use case, precise positioning, and connection density.

– **Massive communication**: This usage scenario extends massive Machine Type Communication (mMTC) of IMT-2020 and involves connection of massive number of devices or sensors for a wide range of use cases and applications.

 Typical use cases include expanded and new applications in smart cities, transportation, logistics, health, energy, environmental monitoring, agriculture, and many other areas such as those requiring a variety of IoT devices without battery or with long-life batteries.

 This usage scenario would require support of high connection density, and depending on use cases, different data rates, low power consumption, mobility, extended coverage, and high security and reliability.

[5D/441 India]

– **Ubiquitous Connectivity**: This usage scenario is intended to enhance connectivity with the aim to bridge the digital divide.

 One focus of this usage scenario is to address presently uncovered or scarcely covered areas, particularly rural, remote and sparsely populated areas.

 Typical use cases include, but not limited to, IoT and mobile broadband communication.

– **Artificial intelligence and communication**: This usage scenario would support distributed computing and AI applications. Typical use cases include IMT-2030 assisted automated driving, autonomous collaboration between devices for medical assistance applications, offloading of heavy computation operations across devices and networks, creation of and prediction with digital twins, and others.

 This usage scenario would require support of high area traffic capacity and 5th percentile user data rates, as well as low latency and high reliability, depending on the specific use case. Besides communication aspects, this usage scenario is expected to include a set of new capabilities related to the integration of AI and compute functionalities into IMT‑2030, including data acquisition, preparation and processing from different sources, distributed AI model training, model sharing and distributed inference across IMT systems, and computing resource orchestration and chaining.

– **Integrated sensing and communication**: This usage scenario facilitates new applications and services that require sensing capabilities. It makes use of IMT-2030 to offer wide area multi-dimensional sensing that provides spatial information about unconnected objects as well as connected devices and their movements and surroundings.

 Typical use cases include IMT-2030 assisted navigation, activity detection and movement tracking (e.g., posture/gesture recognition, fall detection, vehicle/pedestrian detection), environmental monitoring (e.g., rain/pollution detection), and provision of sensing data/information on surroundings for AI, XR and digital twin applications.

 Along with the provided communication capabilities, this usage scenario requires support of high-precision positioning and sensing-related capabilities, including range/velocity/angle estimation, object and presence detection, localization, imaging and mapping.

## 8.2 Test environments

Group 1:

A test environment reflects a combination of geographic environment and usage scenario. There are TBD [5D/727 Japan] 7 selected test environments for IMT-2030 as follows:

− ***Indoor Hotspot-IC*:** An indoor isolated environment at offices and/or in shopping malls based on stationary and pedestrian users with very high user density.

− ***Dense Urban-IC*:** An urban environment with high user density and traffic loads focusing on pedestrian and vehicular users.

− ***Rural-IC*:**(*Editor’s Note: LMLC requirement in IC will be discussed under this test environment and/or Rural-UC.*)A rural environment with [5D/721 CHN], [5D/727 Japan] larger and [5D/687 India], continuous wide area coverage, supporting pedestrian, vehicular and high-speed vehicular users for immersive communication.

[5D/727 Japan]

 [5D/441 India] **Note:** ISD of Rural-IC is high-speed that of Rural-UC.

− ***Urban Macro–MC*:** An urban macro environment targeting continuous coverage focusing on a high number of connected machine type devices.

− ***Urban Macro–HRLLC*:** An urban macro environment targeting ultra-reliable and low latency communications.

− ***[Indoor Factory–HRLLC]:*** (*Editor’s Note: Whether to define Indoor Factory-HRLLC for composite requirement is TBD. If yes, use the layout as defined in TR 38.857 (from 3GPP), i.e., Indoor factory layout using InF-SH as a baseline.*). [5D/441 India], [5D/687 India] An indoor factory environment targeting hyper-reliable and low latency communications. [5D/727 Japan] proposes to delete.

Group 2:

Ubiquitous Connectivity (UC)

− [5D/727 Japan] No specific test environment is required for this scenario.

– ***[Rural-UC]*:** [5D/441 India], [5D/687 India] A rural environment with larger but sparser and wide area coverage, supporting stationary, pedestrian, and low speed vehicular users for broadband connectivity. This test environment includes large cells that can be sparsely distributed. User distribution can also be sparse. [5D/727 Japan] proposes to delete.

**Integrated sensing and communication (ISAC)** (*Editor’s Note: Maximum number of ISAC test environments is 2: one indoor and one outdoor test environments.*)

*−* ***Indoor Factory–ISAC*:** An indoor isolated environment at factory halls focusing on devices and objects such as machinery, assembly lines, storage shelves, AGVs, humans, environment objects, etc.

− ***Urban Macro-ISAC /Urban-ISAC:***(*Editor’s Note1: ISD=500M for either. Editor’s Note2: Layout, configurations and sensing targets to be further studied.*) An urban environment with high sensing-target density focusing on objects such as vehicles, UAVs, humans, environment objects, etc.

AI and Communication (AIAC)

No test environment.

TABLE x

Mapping of test environments and usage scenarios

[5D/727 Japan]

|  |  |
| --- | --- |
|  | Group 1 |
| Usage scenarios | IC | HRLLC | MC |
| Test Environments | IndoorHotspot-IC | DenseUrban-IC | Rural-IC | UrbanMacro–HRLLC | UrbanMacro–MC |

|  |  |
| --- | --- |
|  | Group 2 |
| Usage scenarios | UC | ISAC | AIAC |
| Test Environments | N/A | DenseUrban–ISAC | IndoorFactory–ISAC | N/A |

## 8.3 Network layout

No specific topographical details are taken into account in Dense Urban-IC (macro layer) Rural-IC, Urban Macro-MC, and Urban Macro-HRLLC test environments. In the above cases, base stations (BSs) / sites are placed in a regular grid, following hexagonal layout. The simulation will be a wrap-around configuration of 19 sites, each of 3 TRxPs (cells). A basic hexagon layout for the example of three TRxPs per site is the same as shown in Fig. X in § XX of Report [ITU-R M.2135](https://www.itu.int/pub/R-REP-M.2135)-1, where also basic geometry (antenna boresight, cell range, and ISD) is defined. UEs are distributed uniformly over the whole area.

In the following network topology for the selected test environments is described.

### 8.3.1 Indoor Hotspot-IC

The Indoor Hotspot-IC test environment consists of one floor of a building. The height of the floor is 3 m. The floor has a surface of 120 m × 50 m and 12 BSs/sites which are placed in 20 meter spacing as shown in Fig. X, with a LOS probability as defined by channel model in XX, Table X. In Fig. X, internal walls are not explicitly shown but are modelled via the stochastic LOS probability model.

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

Figure x

Indoor Hotspot sites layout



### 8.3.2 Dense Urban-IC

The Dense Urban-IC test environment consists of two layers, a macro layer and a micro layer. The macro-layer base stations are placed in a regular grid, following hexagonal layout with three TRxPs each, as shown in Fig. X below. For the micro layer, there are 3 micro sites randomly dropped in each macro TRxP area (see Fig. X). The micro-layer deployment (e.g., three micro sites per macro TRxP and there is either one or three TRxPs at each micro site) is not defined but should be reported by the proponent. The proponent should describe micro-layer base stations placement method.

Figure x

Sketch of hexagonal site layout



Figure x

Example sketch of dense urban-IC layout



### 8.3.3 Rural-IC

In Rural-IC test environment, the BSs/sites are placed in a regular grid, following hexagonal layout with three TRxPs each, as in the macro layer of the Dense Urban-IC test environment, as shown in Fig. X. For evaluation of the mobility, the same topographical details of hexagonal layout are applied to both 120 km/h and 500 km/h mobility.

For 500 km/h mobility, additional evaluations are encouraged using linear cell layout configuration(s) defined in XX of this Report.

### 8.3.4 Urban Macro-MC and Urban Macro-HRLLC

In the Urban Macro-MC and Urban Macro-HRLLC test environments, the BSs/sites are placed in a regular grid, following hexagonal layout with three TRxPs each, as in the Dense Urban-IC macro layer and Rural-IC test environment; this is shown in Fig. X.

### [5D/441 India]

### 8.3.5 Rural UC

[5D/721 CHN] proposes to delete Rural-UC.

[5D/687 India]

In Rural-UC test environment, the BSs/sites are placed in a grid with sparsity. It will have two layouts possible:

1) The BSs/sites are placed in a regular grid, following hexagonal layout with three TRxPs each, as in the macro layer of the Dense Urban-IC test environment, as shown in Fig. X. For evaluation of the mobility, the same topographical details are applied to stationary, pedestrian, and vehicular mobility.

2) The BSs/sites are placed in sparse deployment appearing a single cell drop as shown in the below. Such deployment is noise limited.

Figure x

Example sketch of Rural-UC layout for single cell drop

Cell Radius = [TBD]

 Cell radius

### 8.3.x Indoor factory ISAC

The Indoor Factory-ISAC test environment consists of one floor of a building [with sparse clutter and high BS](*Editor’s Note: contents inside square brackets will be moved to section 8.4*). The height of the [floor] is [8/10/25] m. The floor has a surface of 300 m × 150 m and [18] BSs/sites which are placed with a spacing of D=[50] meters as shown in Fig. YY. [Each BS/site has fixed height of either 4 or 8 meters]. In Fig. YY, internal walls are not explicitly shown but are modelled via the stochastic LOS probability model.

The type of site deployed (e.g., one TRxP per site or 3 TRxPs per site) is not defined and should be reported by the proponent. A typical factory environment can be modelled with various parameters as listed in Table XX of section 8.4

Figure YY

Indoor Factory sites layout



Editor’s Note: The above figure is a baseline with inter site distance and spacing will be discussed further.

### 8.3.XX Urban [Macro]-ISAC

In the Urban [Macro]- ISAC test environment, the BSs/sites are placed in a regular grid, following hexagonal layout with three TRxPs each as in the Dense Urban-IC macro layer, Rural-IC test environment, Urban Macro-MC and Urban Macro-HRLLC shown in Fig. X. [It is applicable [for both UAV and automotive vehicle] as sensing objects in section 8.4.]

(*Editor’s note: ISD is 500m that will be captured in section 8.4.*)

[5D/721 China][5D/727 Japan]

Example of sensing objectives – Automotive vehicle(s)

In the case of automotive vehicles as sensing targets, the road configuration of urban grid could be considered overlaid on the hexagonal layout, as shown in Fig. ZZZ.

[Editor’s note: Text explaining the wrap-around of cluster of 19-cells shown in Figure ZZZ1 need to be added.]

FIGURE ZZZ

Example layout automotive vehicle as sensing target



Figure ZZZ-1

Example wrap around model for Urban [Macro]-ISAC



## 8.4 Evaluation configurations

Editor’s note: the following table is conclusion from WP 5D #48&49. That is a reference when developing evaluation configuration. The table will be removed after discussions on evaluation configuration and methodologies are complete.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TPRs/Test Environments | Indoor Hotspot–IC | Dense Urban–IC | Rural–IC | Urban macro–MC | [Indoor factory–HRLLC] | Urban macro–HRLLC | [Rural–UC] | Indoor Factory–ISAC | Urban Macro/Urban–ISAC |
| 5th percentile user spectral efficiency | x | x | x |  |  |  | [x] |  |  |
| Average spectral efficiency | x | x | x |  |  |  | [x] |  |  |
| Mobility | x | x | [x] |  |  |  | [x] |  |  |
| User experience data rate |  | x |  |  |  |  | [x] |  |  |
| Area traffic capacity | x |  |  |  |  |  |  |  |  |
| Connection density |  |  |  | x |  |  |  |  |  |
| Reliability |  |  |  |  |  | x |  |  |  |
| Energy efficiency[not yet agreement to simulation] |  | [x] | [x] |  |  |  |  |  |  |
| Positioning(max 2 TEs, one indoor, one outdoor) |  |  |  |  |  |  |  | x | x |
| Sensing(1)Probabilities of detection and false alarm 2) localization accuracy3) velocity(max 2 TEs, one indoor, one outdoor) |  |  |  |  |  |  |  | x | x |
| [Coverage] |  |  |  |  |  |  | [x] |  |  |
| Composite requirement(*Editor’s note: depending on the decision of TPR.*) |  | [x] |  |  | [x] |  |  |  |  |

Evaluation configurations are defined for the selected test environments. The configuration parameters shall be applied in analytical and simulation assessments of candidate RITs/SRITs. For the cases when there are multiple evaluation configurations under the selected test environment, one of the evaluation configurations under that test environment can be used to test the candidate RITs/SRITs. The technical performance requirement corresponding to that test environment is fulfilled if this requirement is met for one of the evaluation configurations under that specific test environment.

[5D/687 India] [5D/460 CHN]

Editor’s note: Update after the § 9 Evaluation model approach is stable.

[For system-level simulation, there are two channel model variants of primary module for IMT‑2020 evaluation: (1) channel model A and (2) channel model B. Proponents can select either channel model A or B to evaluate the candidate RITs/SRITs. The technical performance requirement corresponding to a test environment is fulfilled if this requirement is met for either channel model A or B for that specific test environment. The same channel model variant should be used to evaluate all the test environments.]

The configuration parameters (and also the propagation and channel models in Annex 1 of this Report) are solely for the purpose of consistent evaluation of the candidate RITs/SRITs and relate only to specific test environments designed for these evaluations. Therefore, the configuration parameters should not be considered as those that must be used in any deployment of any IMT-2020 system, nor should they be taken as the default values for any other or subsequent study in ITU or elsewhere. They do not necessarily themselves constitute any requirements on the implementation of the system. Some configuration parameters are specified in terms of a range of values. This is done to provide some flexibility in the evaluation process. It should be noted that in such cases, meeting the technical performance requirements is not necessarily associated with the lowest/highest value in the range.

[Editor’s note: The summary of discussions on mappings between TPR and test environments is provided in Annex 1.]

[5D/540 Ericsson], [5D/641 ATIS], [5D/721 CHN], [5D/782 Ericsson]

TABLE x

a) Evaluation configurations for Indoor Hotspot-IC test environment

| Parameters | Indoor Hotspot-IC |
| --- | --- |
| Spectral efficiency, mobility, area traffic capacity evaluations, and positioning accuracy and composite requirement evaluations |
| Configuration A | Configuration … |
| **Baseline evaluation configuration parameters** |
| Carrier frequency for evaluation | 4 GHz | 7 GHz |
| BS antenna height | 3 m | 3m |
| Total transmit power per TRxP | 24 dBm/24 dBm per 20 MHz bandwidth21 dBm for 10 MHz bandwidth | 24 dBm for 20 MHz bandwidth21 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm/[26dBm] for TDD | 23 dBm/[26dBm] for TDD |
| **Additional parameters for system-level simulation** |
| Inter-site distance | 20 m | 20 m |
| Number of antenna elements per TRxP | up to 256 | Up to 1024 Tx/Rx/ up to 1024 elements |
| Number of UE antenna elements | Up to 8 | Up to 4Rx or 6Rx or 8Rx/ up to 8 elements |
| Device deployment | 100% indoor, Randomly and uniformly distributed over the areaFor positioning, Randomly and uniformly distributed over the horizontal evaluation, which is at least the convex hull of the horizontal BS deployment | 100% indoor, Randomly and uniformly distributed over the area |
| UE mobility model | Fixed and identical speed |v| of all dropped UEs, randomly and uniformly distributed direction | Fixed and identical speed |v| of all dropped UEs, randomly and uniformly distributed direction |
| UE speeds of interest | 100% indoor, 3 km/h | 100% indoor, 3 km/h |
| Inter-site interference modeling | Ideal muting/ Explicitly modelledIdeal muting for positioning | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB |
| BS antenna element gain | 5 dBi (Single sector antenna) | 5 dBi |
| UE antenna element gain | Omni, 0 dBi (low band) | 0 dBi |
| Thermal noise level | –174 dBm/Hz | –174 dBm/Hz |
| Traffic model | N/A for positioningFull buffer for spectral efficiency, mobility and area traffic capacityTBD for composite requirement | Full buffer for spectral efficiency, mobility and area traffic capacityTBD for composite requirement |
| Simulation bandwidth | 200 MHz/100/200 MHz for positioning100MHz for composite requirementFor spectral efficiency, mobility and area traffic capacity: 20 MHz for TDD, 10 MHz+10 MHz for FDD | 100MHz for composite requirementFor spectral efficiency, mobility and area traffic capacity: 20 MHz for TDD, 10 MHz+10 MHz for FDD |
| UE density | N/A/TBD for positioning10 UEs per TRxPrandomly and uniformly dropped throughout the geographical area | 10 UEs per TRxPrandomly and uniformly dropped throughout the geographical area |
| UE antenna height | 1.5 m | 1.5m |

[5D/540 Ericsson],[5D/641 ATIS], [5D/679 Huawei], [5D/721 CHN], [5D/782 Ericsson]

TABLE x (*continued*)

b) Evaluation configurations for Dense Urban-IC test environment

| Parameters | Dense Urban-IC |
| --- | --- |
| Spectral efficiency, mobility, and positioning accuracy, composite requirement and energy efficiency evaluations | 5th percentile userdata rate |
| Configuration A | Configuration … |  |
| **Baseline evaluation configuration parameters** |
| Carrier frequency for evaluation | 1 layer (Macro) with 4 GHz | 1 layer (Macro) with 7GHz |  |
| BS antenna height | 10 m/25 m | 25m |  |
| Total transmit power per TRxP | 44 dBm per 20 MHz bandwidth | 44 dBm per 20 MHz bandwidth |  |
| UE power class | 23 dBm/[26 dBm] for TDD | 23 dBm/[26 dBm] for TDD, 26 dBm for TDD | 23 dBm/[26 dBm] for TDD |
| Percentage of high loss and low loss building type  | TBD/20% high loss, 80% low loss | 20% high loss, 80% low loss | 20% high loss, 80% low loss |
| **Additional parameters for system-level simulation** |
| Inter-site distance | 200 m | 200 m |  |
| Number of antenna elements per TRxP | Up to 256 | Up to 1024 Tx/Rx /up to 1024 elements/ Up to 2048 Tx/Rx |  |
| Number of UE antenna elements | Up to 8 | Up to 4Rx or 6Rx or 8Rx / up to 8 elements/ Up to 16 Tx/Rx\*\*Possible device types include handheld device, CPE, vehicle etc. Configurations of antenna element more than certain number are not necessarily applicable to all device types. |  |
| Device deployment | 100% outdoor, Randomly and uniformly distributed over the area/80% indoor, 20% outdoor (in‑car)Randomly and uniformly distributed over the area under Macro layer | 80% indoor, 20% outdoor (in‑car)Randomly and uniformly distributed over the area under Macro layer | 80% indoor, 20% outdoor (in‑car)Randomly and uniformly distributed over the area under Macro layer |
| UE mobility model | TBD / Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction. | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction. | Fixed and identical speed |v| of all UEs of the same mobility class, randomly and uniformly distributed direction. |
| UE speeds of interest | 3 km/h/ Indoor users: 3 km/hOutdoor users (in-car): 30 km/h | Indoor users: 3 km/hOutdoor users (in-car): 30 km/h | Indoor users: 3 km/hOutdoor users (in-car): 30 km/h |
| Inter-site interference modelling | Ideal muting/ Explicitly modelledIdeal muting for positioning | Explicitly modelledIdeal muting for positioning | Explicitly modelled |
| BS noise figure | 5 dB | 5dB | 5dB |
| UE noise figure | 7 dB | 7 dB | 7 dB |
| BS antenna element gain | 8 dBi | 8dBi | 8dBi |
| UE antenna element gain | 0 dBi | 0dBi | 0dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | N/A for positioningFull buffer for spectral efficiency and mobility TBD for composite requirementFTP model 3 (0.5MB as packet size, 200ms as mean inter-arrival time) for energy efficiency | TBD/N/A for positioningFull buffer for spectral efficiency and mobility TBD for composite requirementFTP model 3 (0.5MB as packet size, 200ms as mean inter-arrival time) for energy efficiency | Full buffer |
| Simulation bandwidth | 200 MHz/100/200 MHz for positioning100MHz for composite requirement TBD for energy efficiencyAverage and 5th percentile user spectral efficiency: 20 MHz for TDD,10 MHz+10 MHz for FDD | 100/200 MHz for positioning100 MHz for composite requirement TBD for energy efficiencyAverage and 5th percentile user spectral efficiency: 20 MHz for TDD,10 MHz+10 MHz for FDD | Reported by proponent |
| UE density | N/A10 UEs per TRxPRandomly and uniformly distributed over the area under Macro layerTBD for positioning | 10 UEs per TRxPRandomly and uniformly distributed over the area under Macro layerTBD for positioning | 10 UEs per TRxP for multi-layer case, randomly and uniformly dropped within a cluster. The proponent reports the size of the cluster |
| UE antenna height | 1.5 m/Outdoor UEs: 1.5 mIndoor UTs: 3(*nfl* – 1) + 1.5; *nfl* ~ uniform(1,*Nfl*) where *Nfl* ~ uniform(4,8) | Outdoor UEs: 1.5 mIndoor UTs: 3(*nfl* – 1) + 1.5; *nfl* ~ uniform(1,*Nfl*) where *Nfl* ~ uniform(4,8) | Outdoor UEs: 1.5 mIndoor UTs: 3(*nfl* – 1) + 1.5; *nfl* ~ uniform(1,*Nfl*) where *Nfl* ~ uniform(4,8) |

[5D/679 Huawei], [5D/721 CHN], [5D/782 Ericsson]

TABLE x (*continued*)

c) Evaluation configurations for Rural-IC test environment

| Parameters | Rural-IC |
| --- | --- |
| Spectral efficiency and mobility, and energy efficiency evaluations |
| Configuration A | Configuration … |
| **Baseline evaluation configuration parameters** |
| Carrier frequency for evaluation | 700 MHz | 7GHz |
| BS antenna height | 35 m | 35 m |
| Total transmit power per TRxP | 49 dBm for 20 MHz bandwidth46 dBm for 10 MHz bandwidth | 49 dBm for 20 MHz bandwidth46 dBm for 10 MHz bandwidth |
| UE power class | 23 dBm | 23 dBm, 26 dBm for TDD |
| Percentage of high loss and low loss building type | 100% low loss | 100% low loss |
| **Additional parameters for system-level simulation** |
| Inter-site distance | 1 732 m | 1 732 m |
| Number of antenna elements per TRxP |  |  up to 1024 elements/ Up to 2048 Tx/Rx |
| Number of UE antenna elements |  | up to 8 elements/ Up to 16 Tx/Rx\*\*Possible device types include handheld device, CPE, vehicle, etc. Configurations of antenna element more than certain number are not necessarily applicable to all device types. |
| Device deployment | 50% indoor, 50% outdoor (in‑car)Randomly and uniformly distributed over the area | 50% indoor, 50% outdoor (in‑car)Randomly and uniformly distributed over the area |
| UE mobility model | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction |
| UE speeds of interest | Indoor users: 3 km/h;Outdoor users (in-car): 120 km/h;500 km/h for evaluation of mobility in high-speed case | Indoor users: 3 km/h;Outdoor users (in-car): 120 km/h;500 km/h for evaluation of mobility in high-speed case |
| Inter-site interference modelling | Explicitly modelled | Explicitly modelled |
| BS noise figure | 5 dB | 5 dB |
| UE noise figure | 7 dB | 7 dB |
| BS antenna element gain | 8 dBi | 8 dBi |
| UE antenna element gain | 0 dBi | 0 dBi |
| Thermal noise level | ‒174 dBm/Hz | ‒174 dBm/Hz |
| Traffic model | Full buffer for spectral efficiency and mobility FTP model 3 (0.5MB as packet size, 200ms as mean inter-arrival time) for energy efficiency | Full buffer for spectral efficiency and mobility FTP model 3 (0.5MB as packet size, 200ms as mean inter-arrival time) for energy efficiency |
| Simulation bandwidth | For spectral efficiency, mobility 20 MHz for TDD, 10 MHz+10 MHz for FDDTBD for energy efficiency | For spectral efficiency, mobility 20 MHz for TDD, 10 MHz+10 MHz for FDDTBD for energy efficiency |
| UE density | 10 UEs per TRxPRandomly and uniformly distributed over the area | 10 UEs per TRxPRandomly and uniformly distributed over the area |
| UE antenna height | 1.5 m | 1.5 m |

TABLE x (*continued*)

d) Evaluation configurations for Urban Macro-MC test environments

| Parameters | Urban Macro-MC |
| --- | --- |
| Connection density evaluation |
| Configuration A | Configuration … |
| **Baseline evaluation configuration parameters** |
| Carrier frequency for evaluation |  |  |
| BS antenna height |  |  |
| Total transmit power per TRxP[[3]](#footnote-3) |  |  |
| UE power class |  |  |
| Percentage of high loss and low loss building type  |  |  |
| **Additional parameters for system-level simulation** |
| Inter-site distance |  |  |
| Number of antenna elements per TRxP |  |  |
| Number of UE antenna elements |  |  |
| Device deployment |  |  |
| UE mobility model |  |  |
| UE speeds of interest |  |  |
| Inter-site interference modelling |  |  |
| BS noise figure |  |  |
| UE noise figure |  |  |
| BS antenna element gain |  |  |
| UE antenna element gain |  |  |
| Thermal noise level |  |  |
| Traffic model |  |  |
| Simulation bandwidth |  |  |
| UE density |  |  |
| UE antenna height |  |  |

TABLE x (*continued*)

e) Evaluation configurations for Urban Macro-HRLLC test environments

| Parameters | Urban Macro-HRLLC |
| --- | --- |
| Reliability evaluation |
| Configuration A | Configuration … |
| **Baseline evaluation configuration parameters** |
| Carrier frequency for evaluation |  |  |
| BS antenna height |  |  |
| Total transmit power per TRxP |  |  |
| UE power class |  |  |
| Percentage of high loss and low loss building type  |  |  |
| **Additional parameters for system-level simulation** |
| Inter-site distance |  |  |
| Number of antenna elements per TRxP1 |  |  |
| Number of UE antenna elements |  |  |
| Device deployment |  |  |
| UE mobility model |  |  |
| UE speeds of interest |  |  |
| Inter-site interference modelling |  |  |
| BS noise figure |  |  |
| UE noise figure |  |  |
| BS antenna element gain |  |  |
| UE antenna element gain |  |  |
| Thermal noise level |  |  |
| Traffic model |  |  |
| Simulation bandwidth |  |  |
| UE density |  |  |
| UE antenna height |  |  |

[5D/721 CHN]

TABLE x (*continued*)

f) Evaluation configurations for Indoor Factory-ISAC test environment

| Parameters | Indoor Factory-ISAC |
| --- | --- |
| Positioning Evaluations | [Sensing evaluations (Detection probability, localization accuracy and velocity accuracy)] |
| **Baseline evaluation configuration parameters** |
| Carrier frequency for evaluation | 4GHz |  |
| BS antenna height | Opt1: 8mOpt2: Each BS/site has fixed height of either 4 or 8 meters. |  |
| Total transmit power per TRxP | 24 dBm |  |
| UE power class | 23 dBm |  |
| **Additional parameters for system-level simulation** |
| Inter-site distance | 50m |  |
| Number of antenna elements per TRxP |  |  |
| Number of UE antenna elements |  |  |
| Device deployment | 100% indoorUniformly distributed over the horizontal evaluation area, which is at least the convex hull of the horizontal BS deployment. |  |
| UE mobility model | Fixed and identical speed |v| of all UEs, randomly and uniformly distributed direction |  |
| UE speeds of interest | 100% indoor, 3 km/h |  |
| Inter-site interference modelling | Ideal muting |  |
| BS noise figure | 5 dB |  |
| UE noise figure | 7 dB |  |
| BS antenna element gain | 5 dBi |  |
| UE antenna element gain | 0 dBi |  |
| Thermal noise level | ‒174 dBm/Hz |  |
| Simulation bandwidth | 100MHz/200MHz |  |
| UE antenna height | Opt 1: 1.5mOpt 2: Uniformly distributedwithin [0.5, 2]m |  |

[5D/540 Ericsson]

TABLE x

Additional evaluation parameters for sensing

| Parameters | Values |
| --- | --- |
| Link level abstraction | Explicit simulation of all links. |
| Radio sensing signal | Tx: BS1, Rx: BS2 | [Tx: BS, Rx: UE] |
| Radio sensing channel model | e.g., geometry-based stochastic channel model.Needs to capture the sensing object reflections and the clutter impact. |
| BS | BS antenna radiation pattern and configuration | Directional (e.g., reuse network planning for communication without direction optimization for sensing, otherwise configuration is to be clarified by proponent) |
| BS antenna height |  |
| BS tx power for sensing signals | No boosting49 dBm (20 MHz) |
| UE (for scenarios with UE involvement) | UE dropping procedure | – | [Random, based on some rules for fixed-location UEs] |
| UE antenna radiation pattern and configuration | – | [Omni (0 dBi) or directional] |
| UE height | – | [3 m] |
| Min. BS-UE distance (2D), m | – | [35 m] |
| UE mobility (for modelling Doppler effects) | – | [0 km/h (fixed UEs)] |
| Passive (non-connected) sensing target object | Object dropping procedure | Random, based on some rules.e.g., N per cell (N ≥ 1). |
| Object height | Depends on object type.UAV: Random within a range. |
| Object mobility | Depends on object type |
| (tx, rx) pairs for the object | [Rule-based TBD] |
| Interference model |  |

[5D/687 India]

table X

X) Evaluation configurations for Rural-UC test environment

| Parameters | Rural-UC |
| --- | --- |
| Coverage |
| Configuration A | Configuration B |
| **Baseline evaluation configuration parameters** |
| Carrier frequency for evaluation |  |  |
| BS antenna height |  |  |
| Total transmit power per TRxP |  |  |
| UE power class |  |  |
| Percentage of high loss and low loss building type |  |  |
| **Additional parameters for system-level simulation** |
| Number of antenna elements per TRxP |  |  |
| Number of UE antenna elements |  |  |
| Device deployment |  |  |
| UE mobility model |  |  |
| UE speeds of interest |  |  |
| Inter-site interference modelling |  |  |
| BS noise figure |  |  |
| UE noise figure |  |  |
| BS antenna element gain |  |  |
| UE antenna element gain |  |  |
| Thermal noise level |  |  |
| Traffic model |  |  |
| Simulation bandwidth |  |  |
| UE density |  |  |
| UE antenna height |  |  |

table X

Y) Evaluation configurations for Rural-UC test environment

| Parameters | Rural-UC |
| --- | --- |
| 5th percentile, average spectral efficiency and user experience data rate |
|  |
| Configuration A | Configuration B |
| **Baseline evaluation configuration parameters** |
| Carrier frequency for evaluation |  |  |
| BS antenna height |  |  |
| Total transmit power per TRxP |  |  |
| UE power class |  |  |
| Percentage of high loss and low loss building type |  |  |
| **Additional parameters for system-level simulation** |
| cell radius  |  |  |
| Number of antenna elements per TRxP |  |  |
| Number of UE antenna elements |  |  |
| Device deployment |  |  |
| UE mobility model |  |  |
| UE speeds of interest |  |  |
| Inter-site interference modelling |  |  |
| BS noise figure |  |  |
| UE noise figure |  |  |
| BS antenna element gain |  |  |
| UE antenna element gain |  |  |
| Thermal noise level |  |  |
| Traffic model |  |  |
| Simulation bandwidth |  |  |
| UE density |  |  |
| UE antenna height |  |  |

Note 1: Configuration A corresponds to a typical UE at a height of 1.5m and lower cell edge distance and Configuration B corresponds to a typical outdoor UE at a height of 5m with an isolated cell and higher cell edge distance.

Note 2: Cell radius is taken as cell edge distance from the coverage TPR in section 4.10 of Recommendation ITU-R M.[IMT‑2030.TECH PERF REQ]

TABLE x

Additional parameters for link-level simulation
(for mobility, reliability, connection density requirements)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters | Indoor hotspot-IC | DenseUrban-IC | Rural-IC | UrbanMacro-MC | UrbanMacro-HRLLC |
| Evaluated service profiles |  |  |  |  |  |
| Simulation bandwidth |  |  |  |  |  |
| Number of users in simulation |  |  |  |  |  |
| Packet size |  |  |  |  |  |
| Inter-packet arrival time |  |  |  |  |  |

TABLE x

Evaluation configuration parameters for analytical assessment of peak data rate, peak spectral efficiency

| Parameters | Values |
| --- | --- |
| Number of BS antenna elements |  |
| Number of UE antenna elements | [5D/684 Apple]700 MHz / 4 GHz / 7 GHz: Up to 8 Tx /Rx30 GHz: Up to 32 Tx /Rx70 GHz: Up to 64 Tx /Rx |

[5D/460 CHN]

Editor’s note: Update after the § 9 Evaluation model approach is stable.

[TABLE x

Additional channel model parameters for link-level simulation

| Parameters | Indoor Hotspot-IC(for mobility) | Dense Urban-IC(for mobility) | Rural-IC(for mobility) | UrbanMacro-IC(for connection density) | UrbanMacro-IC(for reliability) |
| --- | --- | --- | --- | --- | --- |
| Link-level channel model |  |  |  |  |  |
| Delay spread scaling parameter (s) |  |  |  |  |  |
| AoA, AoD, ZoA angular spreads scaling parameter  (degree) |  |  |  |  |  |
| ZoD angular spreads scaling parameter  (degree) |  |  |  |  |  |

]

## 8.5 Antenna characteristics

This sub-section specifies the antenna characteristics, e.g., antenna pattern, gain, side-lobe level, orientation, etc., for antennas at the BS and the UE, which shall be applied for the evaluation in test environments with the hexagonal grid layouts and/or the non-hexagonal layouts. The characteristics do not form any kind of requirements and should be used only for the evaluation.

### 8.5.1 BS antenna

– BS antennas are modelled having one or multiple antenna panels, where an antenna panel has one or multiple antenna elements placed vertically, horizontally or in a two‑dimensional array within each panel.

– An antenna panel has *M*×*N* antenna elements, where *N* is the number of columns and *M* is the number of antenna elements with the same polarization in each column. The antenna elements are uniformly spaced with a centre-to-centre spacing of *dH* and *dV* in the horizontal and vertical directions, respectively. The *M*×*N* elements may either be single polarized or dual polarized.

– When the BS has multiple antenna panels, a uniform rectangular panel array is modelled, comprising *MgNg* antenna panels where *Mg* is number of panels in a column and *Ng* is number of panels in a row. Antenna panels are uniformly spaced with a center-to-center spacing of *dg,H* and *dg,V* in the horizontal and vertical direction respectively. See Fig. x for an illustration of the BS antenna model.

FIGURE x

BS antenna model



The proponent and evaluator shall report the antenna polarization and the value of *M*, *N*, *Mg*, *Ng*, (*dH*, *dV*) and (*dg,H*, *dg,V*) in their evaluation, respectively.

For antenna element pattern, the general form of antenna element horizontal radiation pattern is specified as:

 

where −180º ≤  ≤ 180º, min [.] denotes the minimum function,  is the horizontal 3 dB beamwidth and *SLA*is the maximum side lobe level attenuation. The general form of antenna element vertical radiation pattern is specified as:

 

where 0º ≤  ≤ 180º, θ3dB is the vertical 3 dB beamwidth and  is the tilt angle. Note that points to the zenith and points to the horizon. The combined vertical and horizontal antenna element pattern is then given as:

 

where  is the relative antenna gain (dB) of an antenna element in the direction .

The BS side antenna element pattern for Dense Urban-IC (macro TRxP), Rural-IC, Urban Macro-MC and Urban Macro-HRLLC test environments are provided in Table X.

For Indoor Hotspot-IC test environment, the BS side antenna element pattern is provided in Table X.

TABLE x

3-TRxP BS antenna radiation pattern

|  |  |
| --- | --- |
| Parameters | Values |
| Antenna element vertical radiation pattern (dB) |  |
| Antenna element horizontal radiation pattern (dB) |  |
| Combining method for 3D antenna element pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* | 8 dBi |

TABLE x

Indoor BS antenna radiation pattern – Ceiling-mount antenna pattern

|  |  |
| --- | --- |
| Parameters | Values |
| Antenna element vertical radiation pattern (dB) |  |
| Antenna element horizontal radiation pattern (dB) |  |
| Combining method for 3D antenna element pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* | 5 dBi |

#### 8.5.1.1 BS antenna orientation

The antenna bearing is defined as the angle between the main antenna lobe centre and a line directed due east given in degrees. The bearing angle increases in a clockwise direction. Figure X shows the hexagonal cell and its three TRxPs with the antenna bearing orientation proposed for the simulations with three-TRxP sites. The centre directions of the main antenna lobe in each TRxP point to the corresponding side of the hexagon.

FIGURE x

Antenna bearing orientation diagram



### 8.5.2 UE antenna

There are two options for UE side antenna element pattern. For XXX(carrier frequency) evaluation, Omni-directional antenna element is assumed.

For XX GHz and XX GHz evaluation, the directional antenna panel is assumed. In this case, the antenna pattern is defined in Table X, and the *MgNg*antenna panels may have different orientations. Introduce  as the orientation angles of the panel  , where the orientation of the first panel  is defined as the UE orientation,  is the array bearing angle and  is the array downtilt angle defined in XX, § XX (coordinate system).

TABLE x

UE antenna radiation pattern model for XXX GHz

|  |  |
| --- | --- |
| Parameters | Values |
| Antenna element radiation pattern in $θ''$ dim (dB) |  |
| Antenna element radiation pattern in $φ''$ dim (dB) |  |
| Combining method for 3D antenna element pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* |  |

# 9 Evaluation model approach

Editor’s note: In upcoming meetings, SWG EVAL will consider input contributions to develop channel models. These will be based on Report [ITU-R M.2412](https://www.itu.int/pub/R-REP-M.2412) (from IMT-2020) as a baseline. There is need to update the IMT-2020 channel model to support the evaluation of new Test Environments and Technical Performance Requirements (TPRs) for IMT-2030.

# 10 List of acronyms and abbreviations

Annex 1

Conclusions from ITU-R Working Party 5D #48 meeting

Attachment 1

Discussion on test environments



Attachment 2

Summary of evaluation methodologies

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Attachment 3

Mappings between test environments and TPR



Annex 2

Conclusions from ITU-R Working Party 5D #49 meeting



1. The interference means the effective interference received at the base station. [↑](#footnote-ref-1)
2. The confidence interval and the associated confidence level indicate the reliability of the estimated parameter value. The confidence level is the certainty (probability) that the true parameter value is within the confidence interval. The higher the confidence level the larger the confidence interval. [↑](#footnote-ref-2)
3. This/these parameter(s) is/are used for cell association. [↑](#footnote-ref-3)