**3GPP TSG-RAN WG4 Meeting #114** **R4-2500686**

**Athens, Greece, 17– 21 February, 2025**

**Agenda item: 7.24.4**

**Source:** Moderator (CMCC)

**Title:** Topic summary for [114][134] A-IoT\_device

**Document for:** Information

# Introduction

This summary focuses on the R19 ambient IOT work item under agenda 7.24.1, 7.24.2.2, 7.24.2.3, including general, device and OTA requirements.

|  |  |  |  |
| --- | --- | --- | --- |
| **TDoc** | **Title** | **Source** | **Agenda item** |
| **[R4-2500402](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500402.zip)** | Discussion on Ambient IoT deployment scenario in Rel-19 | Qualcomm Incorporated | 7.24.1 |
| **[R4-2500639](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500639.zip)** | Discussion on AIoT system parameters | Xiaomi | 7.24.1 |
| **[R4-2500743](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500743.zip)** | Discussion on the system parameter of AIoT | vivo | 7.24.1 |
| **[R4-2500781](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500781.zip)** | A-IoT general aspects | Huawei, HiSilicon | 7.24.1 |
| [**R4-2500875**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500875.zip) | Ambient IoT Work Item work plan | CMCC, Huawei, T-Mobile USA | 7.24.1 |
| [**R4-2500876**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500876.zip) | Discussion on system parameters for A-IOT | CMCC | 7.24.1 |
| **[R4-2501792](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2501792.zip)** | general aspects | OPPO | 7.24.1 |
| **[R4-2501867](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2501867.zip)** | Discussions on General aspect for A-IoT | ZTE Corporation, Sanechips | 7.24.1 |
| **[R4-2502099](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2502099.zip)** | A-IoT general overview | Ericsson | 7.24.1 |
| [**R4-2500778**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500778.zip) | Discussion on system parameters for ambient IoT | Spreadtrum,UNISOC | 7.24.2 |
| [**R4-2500490**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500490.zip) | Ambient IoT device requirements | Qualcomm Incorporated | 7.24.2.2 |
| [**R4-2500614**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500614.zip) | Discussion on RF requirements for ambient IoT device 1 | Spreadtrum,UNISOC | 7.24.2.2 |
| [**R4-2500640**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500640.zip) | Discussion on AIoT device 1 RF requirements | Xiaomi | 7.24.2.2 |
| [**R4-2500745**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500745.zip) | Discussion on the RF requirement for device 1 | vivo | 7.24.2.2 |
| [**R4-2500878**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500878.zip) | Discussion on device RF requirements for A-IOT | CMCC | 7.24.2.2 |
| [**R4-2500999**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500999.zip) | Discussion on Ambient IoT device 1 RF requirements | CATT | 7.24.2.2 |
| [**R4-2501155**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2501155.zip) | RF requirements of ambient IoT device 1 | Sony | 7.24.2.2 |
| [**R4-2501795**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2501795.zip) | RF requirements for device 1 | OPPO | 7.24.2.2 |
| [**R4-2501869**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2501869.zip) | Discussion on RF requirement of Ambient IoT device | ZTE Corporation, Sanechips | 7.24.2.2 |
| [**R4-2502100**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2502100.zip) | A-IoT device requirement overview | Ericsson | 7.24.2.2 |
| [**R4-2502235**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2502235.zip) | On the RF requirements for Ambient IoT Device | Huawei, HiSilicon | 7.24.2.2 |
| [**R4-2502261**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2502261.zip) | Discussion on RF requirement for device 1 | LG Electronics UK | 7.24.2.2 |
| [**R4-2500209**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500209.zip) | on OTA tests for ambient IoT devices | Huawei, HiSilicon | 7.24.3 |
| [**R4-2500401**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500401.zip) | Discussion on Ambient IoT Testability | Qualcomm Incorporated | 7.24.3 |
| [**R4-2500747**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2500747.zip) | Discussion on the OTA test method for device | vivo | 7.24.3 |
| [**R4-2501156**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2501156.zip) | Consideration on the OTA test of ambient IoT device 1 | Sony | 7.24.3 |
| [**R4-2501623**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2501623.zip) | Discussion on OTA testing for A-IoT device 1 | Ericsson-LG Co., LTD | 7.24.3 |
| [**R4-2501793**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2501793.zip) | OTA test method for AIOT device 1 | OPPO | 7.24.3 |
| [**R4-2501974**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_114/Docs/R4-2501974.zip) | Discussion on OTA test method for A-IoT device | CAICT | 7.24.3 |

# Work plan

R4-2500875 Ambient IoT Work Item work plan CMCC, Huawei, T-Mobile USA

**Recommended WF:**

Endorse the work plan for Rel-19 Ambient IOT work item

# System parameters

## Topic 2-1: System parameters

**Issue 2-1-1: Operating band**

Proposal 1 (Xiaomi): Band 8 is defined as the operating band for ambient IoT in R19.

Proposal 2 (Huawei): NR band n8 can be used as an example band. Other FDD bands are not precluded, such as sub 1G bands.

Proposal 3 (ZTE): propose RAN4 to discuss the supported frequency range at device side to further determine the supported NR bands for A-IoT system.

Proposal 4 (Ericsson): HD-FDD should be specified for band n8.

Proposal 5 (Spreadtrum): FR1 licensed spectrum in FDD could be operating band in R19 WI.

**Recommended WF:**

Band n8 is the example band as captured in the WID.

HD-FDD should be specified for band n8.

Further discuss whether to define operating band other than band n8.

ZTE: Regarding Ericsson proposal, that is correct for HD-FDD. For other bands, they depend on commercial interests. Properly band n5 can also be supported.

Moderator: clarify whether other bands are precluded or not.

Ericsson: in SI, we mentioned 2GHz too. From the scope, we have quite limited time. If other bands are included, we need simulation for co-existence.

Sony: We have the specific duplex mode. Can we agree on HD-FDD?

Moderator: The common understanding is that HD-FDD mode is used.

Ericsson: HD-FDD has impact such that CW cannot be transmitted together with R2D to avoid the disturb to R2D reception. What is the Rx bandwidth for device?

Qualcomm: FDD and TDD makes sense when discussing reader. For device, we need define what HD-FDD is? Device needs receive CW and transmit simultaneously. It is up to RAN1.

Ericsson: HD-FDD can be used for BS side.

**Agreement:**

* NR band n8 can be used as an example band, and other FDD bands below 1GHz are not precluded.

**Issue 2-1-2: R2D transmission bandwidth definition**

Proposal (Xiaomi): The transmission bandwidth definition in TR 38.769 can be reused.

**Recommended WF:**

Reuse the following definition of R2D transmission bandwidth in TR38.769

Transmission bandwidth, Btx,R2D from a reader perspective: The frequency resources used for transmitting R2D. For an OFDM-based waveform with subcarrier spacing of 15 kHz.

**Xiaomi: the second sentence is not needed in the second bullet.**

**Ericsson: we should base the agreement on the WI conclusion.**

**Moderator: that is R2D transmission bandwidth.**

**Agreement:**

* Reuse the following definition of R2D transmission bandwidth in TR38.769
* Transmission bandwidth, Btx,R2D from a reader perspective: The frequency resources used for transmitting R2D.
* RAN4 will re-visit the two agreed bullets above, if RAN1 has the different conclusion.

**Issue 2-1-3: R2D channel bandwidth definition**

|  |
| --- |
| Definition of occupied bandwidth in TR38.769* Occupied bandwidth, Bocc,R2D from a reader perspective: The frequency resources used for transmitting R2D, and potential guard band.
 |

Proposal 1(Xiaomi):

For Ambient IoT, the occupied bandwidth name in TR 38.769 is replaced by channel bandwidth for both R2D

- BWChannel, R2D RF bandwidth supporting a single ambient IoT channel with R2D transmission at the reader.

Proposal 2 (Spreadtrum): C

hannel bandwidth for R2D could be two ways.
- Alt1: Reusing the following equation in NR: GBchannel = (BWChannel x 1000 (kHz) - NRB x SCS x 12) / 2 - SCS/2. GBchannel=1/10 transmission bandwidth.

-Alt2: GBchannel plus transmission bandwidth, GBchannel=1/10 transmission bandwidth.

**Recommended WF:**

Define R2D channel bandwidth as:

* Channel bandwidth, BCH,R2D from a reader perspective: The frequency resources used for transmitting R2D, and potential guard band.

**OPPO: we have different understanding as Ericsson to remove potential. We think in-band and standalone requirements are slightly different.**

**ZTE: to OPPO, for in-band, the carrier bandwidth is still 10 and 5MHz. A-IoT always works as standalone. In-band and guard operation, the channel bandwidth should be the same. For A-IoT, we did not share the power between NR and A-IoT.**

**Huawei: Echo to ZTE. The difference is that for A-IoT we have agreement for Rel-19 that we do not have A-IoT and NR share the hardware. It can be viewed as in-band regardless in-band or guardband.**

**Ericsson: Channel bandwidth is used for testing UE and BS. We can configure in-band but we still test contiguous device with the specific bandwidth.**

**Moderator: Share the similar view as ZTE and Huawei. A-IoT BS only transmits the A-IoT signals.**

**Tentative Agreement:**

* Define R2D channel bandwidth as:
* Channel bandwidth, BCH,R2D from a reader perspective: The frequency resources used for transmitting R2D, and guard band.

**Issue 2-1-4: Values of R2D bandwidth**

Proposal 1 (vivo): It is suggested RAN4 to discuss the candidate channel bandwidth and corresponding transmission bandwidth for R2D, and 200kHz/1RB, 800kHz/4RB, 2.4MHz/12RB with 15kHz SCS can be considered.

Proposal 2 (Huawei): Specify 4 types of R2D channel bandwidths corresponding to transmission bandwidth of 1PRB to 4 PRBs.

Proposal 3 (ZTE):

* propose to define the minimum carrier bandwidth (e.g. 0.8MHz) with 4PRB with 15KHz and additional guard band on each side (e.g. 1/18 of R2D transmission bandwidth which is the same as LTE spectrum utilization).
* propose to discuss other carrier bandwidth for R2D transmission until RAN1 has draw the conclusion for the maximum data rate.

Proposal 4 (CMCC): For R2D transmission bandwidth, define 1PRB, 2PRB, 3PRB, 4PRB, whether any guard band is required can be further considered.

Proposal 5 (Ericsson): Wait RAN1 progress on the channel bandwidth and channel arrangement.

**Recommended WF:**

Define R2D transmission bandwidth configuration:

* Option 1: 1PRB, 2PRB, 3PRB, 4PRB with 15KHz SCS
* Option 2: 4PRB with 15KHz SCS

Further discuss the R2D channel bandwidth considering additional guard band.

ZTE: Currently the agreement from RAN1 is 1RB, 2RB, which are minimal RB numbers. We would like to check what the maximum channel bandwidth is. The larger number should also be possible.

Xiaomi: RAN1 further discusses the values and RAN4 need wait for RAN1.

Huawei: We prefer option 1. Although RAN1 did not decide the max numbers, 1~4RBs were decided.

LGE: Similar view as Huawei.

OPPO: we have different understanding. How to define the guardband? The spectrum efficiency should be considered.

Ericsson: Need wait for RAN1 agreement.

Huawei: These values are captured in TR of SI.

Moderator: transmission bandwidth is not in the high priority of RAN1. We prefer to have some agreements.

**Agreement:**

* Define R2D transmission bandwidth configuration:
* 1PRB, 2PRB, 3PRB, 4PRB with 15KHz SCS
* FFS on other RB numbers
* Further discuss the R2D channel bandwidth considering additional guard band.
* If RAN1 has the agreement different than above, RAN4 will revisit the agreements

**Issue 2-1-5: R2D channel raster and channel spacing**

Proposal 1 (Xiaomi):

* Define channel raster for in-band, standalone and guard band as system parameters in both reader and device RF specifications.
* Consider to reuse NR channel raster for ambient IoT system if there’s no implementation cost concern for reader implementation.

Proposal 2 (vivo): Same channel raster and channel spacing as NR can be reused for AIoT R2D.

Proposal 3 (Huawei):

* No need to define channel spacing for A-IoT
* Channel raster for A-IoT BS is 10kHz.

Proposal 4 (CMCC): Define channel raster as 15KHz for R2D.

Proposal 4 (ZTE):

* for R2D transmission in Standalone operation mode, to define the channel raster as 100KHz;
* for R2D transmission in in-band operation mode, to define the channel raster as 100KHz\*N+delta\_offset where delta\_offset could be as [-47.5,-37.5, -27.5, -17.5, -7.5, 0, 2.5,12.5, 22.5,32.5,42.5]KHz.

**Recommended WF:**

Do not define channel spacing for R2D transmission

Define channel raster for R2D transmission. Details need further discussion.

Huawei: Prefer 10KHz as channel raster because of conclusions of enhanced channel raster.

ZTE: From BS, 10Khz could be supported. The reason to have 10KHz is different from enhanced channel raster. Based on in-band operation within NR signal, we have already known the NR raster. For SA, 100KHz could be still reused.

Ericsson: Channel raster is important for in-band operation studied in SI. Transmitted RB allocated to A-IoT BS should be aligned with RB grid for outdoor BS.

Moderator: Keep the channel raster open.

ZTE: Without R2D channel spacing, you will not have multi-carrier.

**Agreement:**

* Do not define channel spacing for R2D transmission
* Define channel raster for R2D transmission.
	+ Details need further discussion.

**Issue 2-1-6: D2R bandwidth**

Proposal 1(vivo): The D2R bandwidth for device 1 is defined based on 2SB transmission and at least the following aspects need to be considered:

* D2R maximum data rate
* Guard band due to the impact of SFO

Proposal 2 (Huawei): When defining the D2R channel bandwidth, consider the impacts of SFO, FDMA and the filter performance.

Proposal 3 (CMCC):

* Define D2R transmission bandwidth of 1SB, define channel bandwidth of 1SB considering 10% SFO impact.
* Define D2R transmission bandwidth and channel bandwidth with an equation, and further discuss whether to define corresponding requirements based on some typical transmission bandwidth. For example:
* D2R transmission bandwidth of 1SB=baseband chip rate
* D2R channel bandwidth of 1SB=baseband chip rate\*1.1
* RAN4 further discuss whether and how to consider small frequency shift and FDMA operation when define D2R bandwidth.

Proposal 4 (ZTE):

* propose not to reuse the PRB configuration or sub-carrier spacing related concept for D2R transmission.
* propose to discuss the carrier bandwidth for D2R until RAN1 has draw the conclusion for the maximum data rate.

Proposal 5 (Ericsson): Wait RAN1 progress on the channel bandwidth and channel arrangement.

Proposal 6 (Spreadtrum):

* D2R channel bandwidth could be postponed until RAN1’s conclusion.
* Whether the channel bandwidth needs to be distinguished between 2SB transmission and 1SB transmission needs to be further discussed.

**Recommended WF:**

Do not use PRB configuration or sub-carrier spacing concept for D2R transmission.

Define D2R channel bandwidth for device 1 considering the following aspects:

* 1SB or 2SB
* D2R data rate (depending on RAN1 conclusion)
* SFO
* FDMA
* Filter performance

Vivo: for the second bullet, it should be D2R max data rate.

Xiaomi: 1 side and 2 side band, only 2-side band can be supported by device 1.

Ericsson: We are not sure for the first bullet. Transmission bandwidth discussed early are the same for transmission and reception.

OPPO: Share the similar view as Xiaomi.

Moderator: for 1 sided band, for device 1 only 2 sided is supported. If you have small frequency shift, you have the gap. It is related to how to define the D2R channel bandwidth.

Qualcomm: Is there multiple DL transmissions for FDMA?

Spreadtrum: for second bullet, 3rd harmonic should be considered.

Sony: We have the similar question as Qualcomm. Any filter is assumed for D2R?

Moderator: for FDMA, the device will have small frequency shift. Different Devices may have different shifts.

CATT: Why is the channel bandwidth dependent on the implementation? Same questions as Qualcomm.

ZTE: to CATT, here the device 1 is very cheap. We have considered some frequency offset and some timing error. How to confine the frequency.

Ericsson: the first bullet is confusing.

Qualcomm: What does option 2 mean?

Xiaomi: we need two channel bandwidths from reader and A-IoT device perspectives.

Agreement:

* D2R channel bandwidth for A-IoT device
	+ Define D2R channel bandwidth for A-IoT device considering the following aspects:
		- [1SB or] 2SB
		- D2R maximum data rate (depending on RAN1 conclusion)
		- SFO
		- FDMA, i.e., considering the different device 1 has different frequency shift
		- Reference Filter performance
		- Other aspects are not precluded

**Issue 2-1-7: D2R channel raster and channel spacing**

Proposal 1 (vivo): It is unnecessary to define channel raster and channel spacing for D2R.

Proposal 2 (ZTE): Regarding the channel raster for D2R transmission, due to the poor frequency stability performance of the device 1, this might be very difficult to maintain the 100KHz freq channel raster as R2D transmission from BS side. Propose to further discuss the channel raster especially considering the poor frequency stability performance.

**Recommended WF:**

Do not define channel raster and channel spacing for D2R

ZTE: from our understanding channel raster is not needed. For channel spacing, we have FDMA. How to define channel spacing for those two devices.

CMCC: so-called channel spacing is related to implementation of scheduling.

Ericsson: FDMA is within RAN1 scope. We can decide channel spacing later.

CATT: From device we do not need. From BS, we may need it to support multi-carriers.

Qualcomm: There are multiple CW which need channel raster. Are we talking about the CW or device.

Huawei: BS cannot support multi-carriers.

**Issue 2-1-8: Foffset for Ambient IoT**

Proposal (Huawei): Apply the Foffset for Ambient IoT as Table 1:

Table 1: Foffset for Ambient IoT

|  |  |
| --- | --- |
| Lowest or Highest Carrier | Foffset |
| Ambient IoT for 1PRB CBW  | 200 kHz |
| Note: Other CBW larger than 1PRB is FFS |

As described in TS36.104, for NB-IoT standalone operation, NB-IoT requirements for receiver and transmitter shall apply with a frequency offset Foffset. A-IoT with one PRB transmission bandwidth is with similar narrow bandwidth, it can be applied to A-IoT. The frequency offset Foffset. values for Other CBW larger than 1PRB can be FFS.

*Copied from TS 36.104*

For NB-IoT standalone operation, NB-IoT requirements for receiver and transmitter shall apply with a frequency offset **Foffset**as defined in Table 5.6-3A.

Table 5.6-3A: Foffset for NB-IoT standalone operation

|  |  |
| --- | --- |
| Lowest or Highest Carrier | Foffset |
| Standalone NB-IoT | 200 kHz |

*Copied form TR36.802*



Figure 7.1.6.2-1: ACLR for NB-IoT standalone

**Recommended WF:**

More discussion is needed.

## Topic 2-2: Others

**Issue 2-2-1: CW spec**

Proposal 1 (ZTE): propose RAN4 to discuss how to capture the RF requirement of CW node in RAN4 specification.

Proposal 2 (Huawei): The Ambient IoT BS spec will contain the RF requirements and the Title is updated to “TS 38.xxx Ambient IoT Base Station (BS) and Carrier-Wave (CW) node radio transmission and reception”

Proposal 3 (Ericsson): Update the WID with adding the CW transmission in new specification title.

**Recommended WF:**

Add CW transmission in the new specification title: “TS 38.xxx Ambient IoT Base Station (BS) and Carrier-Wave (CW) node radio transmission and reception”

Agreement:

* Add CW transmission in the new specification title: “TS 38.xxx Ambient IoT Base Station (BS) and Carrier-Wave (CW) node radio transmission and reception”

**Issue 2-2-2: Deployment scenario**

Proposal 1 (Huawei): Consider only outdoor legacy NR UEs when defining A-IoT BS requirements in R19.

Proposal 2 (Qualcomm):

* If RAN4 agrees to specify RF requirements based on the assumption that NR UE is only outdoor, RAN4 needs to discuss how to address the coexistence issue when legacy NR is indoor.
* The following potential solutions can be considered:
	+ Specify mechanism to ensure legacy NR UE only outdoor
	+ Specify enough frequency offset between NR and A-IoT systems
	+ Specify appropriate RF requirements such as selectivity requirement for the device

Proposal 3 (OPPO): It is encouraged to further study possible solutions for scenario 2-2 when NR UE indoor to protect the reader and also NR

**Recommended WF:**

Discuss whether to specify RF requirements based on the assumption that NR UE is only outdoor in Rel-19.

Qualcomm: based on SI, we identify some issues for NR UE indoor. We have to have some solution for this dedicated scenario. Operator cannot guarantee NR UE moving indoor.

Ericsson: We have similar question as Qualcomm. During SI phase, there are mitigation scheme, which needs indoor BS and we would like to add it in the scope of WI that co-located NR BS should also be considered for impact on RF part.

CATT: To Ericsson, this is out-of-scope of WI.

CMCC: In TR, we captured the existing mechanism. Operator can move UE. In this way, we can avoid the interference issue. The issue is not in the scope of Rel-19.

ZTE: Similar understanding as CMCC. Handover or redirection procedure can be used.

Vivo: We are OK with CMCC proposal. If we only define the requirement based on outdoor, do we need capture it in the spec.

OPPO: We would like to evaluate the mechanism. We can add some clarification in the WID that only outdoor scenario is considered.

Huawei: For indoor NR UE, there are some solutions. Even we set the higher requirement, it cannot solve the issue of indoor UE interference.

Sony: We support to constrain NR UE to outdoor. Support Qualcomm to clearly capture the side condition in the spec.

Agreement:

* To specify RAN4 RF requirements based on the assumption that NR UE is only outdoor in Rel-19.
	+ FFS on whether and how to capture the side condition of outdoor UE assumption in the specifications

**Issue 2-2-3: Spectrum operation mode**

Proposal (ZTE): RAN4 need to clarify the applicable frequency position within NR carrier if R2D/D2R is in-band operation mode.

* For frequency position to place the CW node is not clearly clarified. Since the device 1 could also support some frequency shift compared with operating frequency of CW node, in other words, even though CW signal is placed within the guard band, then it is still possible to have D2R reflection signal to be within in-band spectrum of the coexisting NR carrier.

**Recommended WF:**

Only in-band and standalone spectrum operation mode is within Rel-19 WI scope.

Some clarification on the proposal maybe needed. Is the intention to discuss CW frequency position in guard band?

**Issue 2-2-4: WI scope**

Proposal (Ericsson):

* Update the WID to clarify the general scope of the spectrum deployment for coexisting scope.
* RAN4 to discuss the coexisting for other band than n8 for potential coexisting scope in Rel-19 WID, for example, whether in-door NR deployment also relevant for the generic feature specification of A-IoT.
* Coexisting simulation should be added in Rel-19 to further confirm SA deployment and # of guard RB needed for in-band deployment.
* RAN4 continue on the discussion of the SINR calculation for R2D in coexisting study in work item phase.
* Update the RAN4 objective with adding coexisting study aspect.

**Recommended WF:**

RAN4 had already conducted co-existence evaluation in SI phase. There is no co-existence study within Rel-19 WI. It is recommended to not extend the WI scope due to the tight timeline. Some clarification on the WID if necessary, can be discussed.

# Device RF requirements

## Topic 3-1: General

**Issue 3-1-1: General**

Proposal 1 (Qualcomm): Define reference values as dBm and referred to 0 dBi antenna.

Proposal 2 (vivo): Only the radiated based RF requirement is defined for device 1 in Rel-19 WI

Proposal 3 (Huawei): When specifying radiated performances, the orientation of the device antenna as well as the frequency variation of the antenna and the matching network should be accounted for, in addition to the performance of the RF IC chip.

**Recommended WF:**

Only define radiated RF requirements for device 1 in Rel-19 WI. The details will be further discussed.

Agreement:

* Only define radiated RF requirements for device 1 in Rel-19 WI. The details will be further discussed.

## Topic 3-2: Tx

Conclusions in SI phase:

|  |  |
| --- | --- |
| **A-IoT device TX (D2R) RF Requirement** | **Device 1** |
| Transmit output power | Maximum output power /output power | NO for maximum output powerYES for backscattering power or power backscattering loss |
| Output power dynamic | Transmit OFF power | No  |
| Transmit ON/OFF time mask | NO, as RAN4#112 agreed |
| Minimum output power | N/A |
| Power control  | NO, as RAN4#112 agreed |
| Transmit signal quality | Frequency error | NO, as RAN4#112 agreed |
| Modulation quality requirements | TBD |
| In band emissions  | NO, as RAN4#112 agreed |
| Carrier leakage | NO, as RAN4#112 agreed |
| Output RF spectrum emissions | Occupied bandwidth | YES |
| SEM | TBD |
| ACLR | TBD |
| Spurious emissions | TBD |
| Unwanted emissions | TBD |
| Transmit intermodulation | NO |

**Issue 3-2-1: Transmit output power**

Proposal 1 (Qualcomm): Define a transmit output power requirement so that for specific input power, a predefined output power is expected from the device.

Proposal 2 (Spreadtrum):

* The minimum backscatter modulated power needs to be defined. -34dBm for the minimum backscatter modulated power could be a starting point.
* The backscatter loss needs to be defined. The backscatter loss is 10dB could be a starting point.

Proposal 3 (Xiaomi):

* The backscatter loss L from hardware needs discussion and decision in RAN4.
* The maximum input CW power to calculate device 1 radiated power can be assumed as 3 dBm.

Proposal 4 (vivo):

* The backscatter loss of device can be implicitly defined in radiated power under a fixed incoming source power level.
* The min peak EIRP of device and the certain distance between device and CW source should be defined together.

Proposal 5 (CMCC): For output power, define backscattering power with a typical condition for test or consider device declaration its backscattering power.

Proposal 6 (CATT): The transmitted power of AIoT device 1 shall be specified and verified as the backscattered power level under a given input/CW power level.

Proposal 7 (OPPO): The RF ID regulation output power has already considered the exact backscattering power level and the backscattering power loss. Only one RF output power requirement which is similar to RF ID output power will be defined.

Proposal 8 (Ericsson): Specify the backscatter efficiency requirement for device 1/2a.

Proposal 9 (Huawei): RAN4 to discuss the measurement configuration including incident CW power and orientation for measuring the backscatter power or backscatter loss.

Proposal 10 (LGE): Backscattering power of Device 1 can be calculated:

TBackscaterring power= CW Received power-P\_(loss\_iot\_device )+Antenna Gain

P\_(loss\_iot\_device )=2\*P\_(Backscattering modulator)

Proposal 11 (Sony): The transmitted power of AIoT device 1 shall be specified and verified as the backscattered power level under a given input/CW power level.

**Recommended WF:**

Slightly more companies support to define backscattering power. First to discuss whether both backscattering power and power backscattering low requirements need to be specified for device 1.

If backscattering power is defined, measurement configuration including input CW power and potential other conditions need to be defined.

Ericsson: We prefer to define backscattering loss.

Vivo: We think it is enough to define the radiated power. Backscattering is part of radiated power.

Qualcomm: Backscattering loss is the power ratio.

Huawei: we are open to either define the power and loss. We need consider the measurement configuration including orientation. It could be too early.

Sony: regardless what the metric, we need define the power level.

Agreement:

* + Measurement configuration including input CW power and potential other conditions need to be defined.

**Issue 3-2-2: Modulation quality requirements**

Option 1 (Qualcomm, Xiaomi, vivo, CATT, Sony): Define modulation quality requirements

* Proposal 1(Qualcomm): Define EVM requirements. As part of modulation quality, specify SFO error requirement for the A-IoT Device.
* Proposal 2 (Xiaomi): EVM may not be a suitable methodology for AIoT device 1 Tx modulation quality requirement, BER or BLER can be a candidate for further discussion.
* Proposal 3 (vivo):
	+ For BPSK, the EVM requirement of LTE BPSK can be reused for device, i.e., 17.5%.
	+ For OOK, there is no precedent of modulation quality requirement and a new requirement need to be introduced. Further discuss the following requirement options for OOK modulation quality:
		- Option 1: Power ratio between ON chip and OFF chip.
		- Option 2: The EVM of OOK is defined as the average amplitude difference between normalized transmitted signal and the ideal 1&0 reference signal.
		- Option 3: Wait for the conclusion of LP-WUS.
* Proposal 4 (ZTE): define the EVM requirement similar as RFID with OOK signal considered. For BPSK based D2R design, the legacy EVM requirement need also to be revisited.

Option 2 (Spreadtrum, Ericsson): No need to define modulation quality requirements

* Proposal 1 (Ericsson): discuss whether the modulation signal quality requirement can be depending on backscatter efficiency.
* Proposal 2 (Huawei): The modulation signal quality requirement can be considered as implicitly embedded in other RF or demod requirements. No explicit requirement for devices is needed.

**Recommended WF:**

More companies support to define Modulation quality requirements for device 1. Can we agree with option 1? Then further discuss the details on requirements.

Huawei: We have concern on defining the modulation quality. A-IoT is the new technology. One reference is to use RFID standard as reference, where there is no modulation quality specified. For many tests, it depends on the reader to receive the information.

Ericsson: We prefer not to define the requirements. It is better for proponent to provide how to be specified.

Qualcomm: Agree with Ericsson. We need discussions how it means. Blindly saying modulation quality is not sufficient at this moment.

Sony: We agree Qualcomm. We need some measurement to show the device capable of modulation.

**Issue 3-2-3: Occupied bandwidth**

Proposal 1 (Spreadtrum): Occupied bandwidth needs to be define. The specific value is dependent on the channel bandwidth of D2R.

Proposal 2 (Xiaomi): If OBW is understood as the BW of 99% transmitted power, the OBW can be defined as following,

* The occupied bandwidth for all transmission bandwidth configurations shall be less than the channel bandwidth.

Proposal 3 (ZTE): The legacy OBW requirement could be used as starting point.

Proposal 4 (Huawei): RAN4 to discuss the OBW requirement after defining the system channel bandwidth.

Proposal 5 (vivo): It is suggested to consider not to define the occupied bandwidth for device 1.

**Recommended WF:**

Postpone the discussion after RAN4 draw conclusion on channel bandwidth for D2R

**Issue 3-2-4: Emission requirements**

Proposal 1 (Xiaomi): Unwanted emission or spectrum mask requirement should be defined. The frequency range for the requirement should cover the emission range of SEM and spurious emissions.

Proposal 2 (vivo):

* For simplicity, the unwanted emission for device is defined as EIRP-based requirement at the peak direction to alleviate the test burden for low-cost device.
* It is suggested that only a composite emission mask is defined as unwanted emission requirement for device.

Proposal 3 (CATT): Emission requirements should be defined for Device 1. Meanwhile, the requirement should cover the emission range of SEM and spurious emissions.

Proposal 4 (OPPO):

* To define the spurious emission requirement based on the regulation.
* The SEM requirement is not needed for device 1.

Proposal 5 (Huawei):

* Use NR FR1 SEM requirement as the starting point and further discuss whether to define TRP or EIRP requirement as well as potential simplifications.
* Use NR FR1 general spurious emission requirement as the starting point and further discuss the OOB boundary.

Proposal 6 (CMCC): for emission requirements, use legacy requirements as starting point and adjust the offsets.

Proposal 7(Sony) : RF spectrum emission performance of device 1 needs to be studied, and the corresponding requirements needs to be specified.

**Recommended WF:**

Discuss whether to define one composite emission requirements covering the emission range of SEM and spurious emission.

Discuss whether to define EIRP-based requirements at the peak direction for unwanted emission.

**Issue 3-2-5: Other requirements**

Proposal 1 (Spreadtrum): Output power dynamics are unnecessary to define.

Proposal 2 (Ericsson): no need to specify the intermodulation requirement for device 1.

**Recommended WF:**

Confirm the SI conclusion: Do not define output power dynamics and intermodulation requirements for device 1.

**Issue 3-2-6: Other requirements (frequency error)**

Proposal 1 (Sony): If a small frequency shift is required, the frequency error requirement will need to be specified. The requirement may depend on the system requirements.

Proposal 2 (OPPO): To define the frequency error requirement and also consider the RAN1 conclusion on the small frequency shift.

**Recommended WF:**

It was agreed in SI phase that there is no need to define frequency error. Recommend to deprioritize the discussion.

**Issue 3-2-7: Other requirements (Transmit ON/OFF time mask)**

Proposal 1 (ZTE): propose RAN4 to discuss both ON-OFF/OFF-ON transition time (e.g. 10us transition time) and also the decoding time (e.g. 400us or 500us decoding time) for R2D reception at device side for the appropriate guard period configuration.

**Recommended WF:**

It was agreed in SI phase that there is no need to define transmit ON/OFF time mask for device 1. Recommend to deprioritize the discussion.

## Topic 3-3: Rx

Conclusions in SI phase:

|  |  |
| --- | --- |
| **A-IoT device- RX Requirement** | **Device 1** |
| Reference sensitivity | YES, as RAN4#112 agreed |
| Maximum input power | TBD |
| ACS | NO |
| ACSC | NO |
| In-band blocking | NO |
| Out-of-band blocking | NO |
| Receiver intermodulation | NO |
| Rx spurious emission | NO |
| Spurious response | NO, as RAN4#112 agreed |
| Interference rejection | TBD |

**Issue 3-3-1: Reference sensitivity**

Option 1: Define reference sensitivity using legacy approach

* Proposal 1 (Xiaomi): Success rate can be considered as the criteria for device 1 REFSENS requirement.
* Proposal 2 (vivo):
	+ It is suggested that the Rx requirement of device is defined based on miss detection rate.
	+ It is suggested to consider the device REFSENS is declared by manufacturer and the miss detection rate is less than 10% within a certain period.
* Proposal 3 (Sony):
	+ RAN4 can consider adopt X% miss detection rate as the performance metric to define the REFSENS requirements.
	+ Consider 22 dB NF and 3 dB IM as the starting point to derive the REFSENS.
	+ the REFSENS of AIoT needs to be defined based on the OTA reference plan which is the EIS level at the center of the quiet zone.
* Proposal 4 (Ericsson): Specify both the REFSENS and EH sensitivity.
	+ Wait RAN1 progress for the LLS simulation assumption discussion.
	+ Confirm the 24 dB to be the noise figure of device 1.

Option 2: Define reference sensitivity based on link budget or physical limits of the receiver circuitry

* Proposal 1 (Spreadtrum): The reference sensitivity needs to be defined. -28dBm for the reference sensitivity could be a starting point.
* Proposal 2 (Huawei): Whether and how to define the minimum requirement for device 1 sensitivity, consider the following options:
	+ Alt-1: Do not define compulsory minimum sensitivity requirement. Device vendors follow the specified test method and declare the measured performance;
	+ Alt-2: Define one very relaxed requirement to accommodate diverse implementations tailored for different use cases;
	+ Alt-3: Define the sensitivity requirement as a range (similar to REFSENS for FR2 gNB);
	+ Alt-4: Define multiple levels of sensitivity requirements.

When measuring the radiated sensitivity performance, either TRS as in FR1 or EIS as in FR2 can be considered.

Conventional BLER vs SNR simulations are not needed for determining device sensitivity.

* Proposal 3 (CMCC): REFSENSE requirement can be defined considering device capability or based on device declaration.

**Recommended WF:**

There are different views on reference sensitivity. First to discuss the methodology to define reference sensitivity requirements for device 1.

Huawei: as shown in our paper, we base on -30dBm. The thermal noise will be limited factor. The sensitivity should be limited by analog circuitry.

Sony: the refsen is not activation threshold. Using legacy approach does not preclude consider the circuitry.

For further disccussions:

* Option 1: Define reference sensitivity using legacy approach
* Option 2: Define reference sensitivity based on link budget or physical limits of the receiver circuitry

**Issue 3-3-2: Maximum input power**

Option 1: Define maximum input power requirements

* Proposal 1 (Qualcomm): Define maximum input power for A-IoT Device to apply to all input signals
* Proposal 2 (Spreadtrum): Maximum input power is needed to define. The specific value needs to be further discuss.
* Proposal 3 (Xiaomi): If maximum input power requirement is defined, it should be the R2D signal not CW signal.
* Proposal 4 (vivo): The maximum input power for device 1 is derived based on 1m minimum distance.
* Proposal 5 (Sony): RAN4 studies if there is any negative impact on the RF-ED receiver if the input signal level is too high.

Option 2: Do not define or further discuss the necessary for maximum input power requirements

* Proposal 1 (CATT): The MCL should be discussed first to check if maximum input power requirement is needed. If the MCL needs to be determined, the value of MCL in TR 38.769 could be considered.
* Proposal 2 (Ericsson): Discuss the necessity of specifying the maximum input power by collecting the square law appliance range.
* Proposal 3 (Huawei): RAN4 to discuss whether to define a minimum limit for the maximum input level or allow device vendor to declare the performance based on 3GPP test method.
* Proposal 4 (OPPO): Do not define

**Recommended WF:**

There are different views on the necessary to define maximum input power. More discussion is needed.

**Issue 3-3-3: Interference rejection**

Proposal 1 (Spreadtrum, Xiaomi, CATT, Sony): Do not define interference rejection requirements.

Proposal 2 (Huawei): RAN4 to discuss whether to define a minimum requirement for the interference rejection capability or allow device vendor to declare the performance based on 3GPP test method.

**Recommended WF:**

Majority companies believe interference rejection requirements is not needed for outside topology.

Recommend to not define interference rejection requirements.

# OTA test method

## Topic 4-1: General

**Issue 4-1-1: Scope of OTA test methodology**

Proposal 1 (Huawei): Test methodology for Ambient IoT including

* Chamber setup
* Position of Device
* Test procedures
* Minimum range/ QZ (Quiet Zone) size/QZ calibration
* Preliminary MU assessment

Note: The performance metrics to be discussed in RF (RRM/Demodulation if any) requirements. And the test methodology takes sensitivity and backscatter power as example for discussion to develop unified test methodology.

Proposal 2 (OPPO): For simplification and lower cost, it is proposed only use the EIRP OTA test.

**Recommended WF:**

Need to wait for the conclusion on the RF requirements. Take proposal 1 as starting point.

Huawei:

Agreement:

* For OTA test, the starting point of test methodology for Ambient IoT includes
* Chamber setup
* Position of Device
* Test procedures
* Minimum range/ QZ (Quiet Zone) size/QZ calibration
* Preliminary MU assessment
* Note: The performance metrics to be discussed in RF (RRM/Demodulation if any) requirements. And the test methodology takes sensitivity and backscatter power as example for discussion to develop test methodology.

**Issue 4-1-2: Measurement campaign**

Proposal 1 (Huawei): measurement campaign is not needed in this work item. Refinement in future work items based on measurement campaign is not precluded.

**Recommended WF:**

TBA

**Issue 4-1-3: chamber**

Proposal 1 (Huawei): use anechoic chamber for ambient IoT device tests.

Proposal 2 (vivo): Only focus on the anechoic chamber method for device 1 test in R19.

**Recommended WF:**

Use anechoic chamber for device1 test

**Issue 4-1-4: Energy source**

Proposal 1 (Huawei): The device is assumed energized during the test, and the detailed energizing procedure/energy source is up to implementation, which will not be defined in RAN4 spec.

Proposal 2 (Sony): RAN4 needs to study the device behaviour (availability and unavailability) due to energy harvesting and investigate how it would affect the conformance test design.

Proposal 3 (Ericsson): A-IoT device 1 Energy Storage Unit (ESU) should be fully charged before begging testing for TRP and TRS.

**Recommended WF：**

TBA

## Topic 4-2: Test method and configurations

**Issue 4-2-1: Test configuration**

Proposal 1 (Huawei): test configuration is for a single device under free space condition.

Proposal 2 (CAICT): Adopt Free Space testing configuration for A-IoT device OTA testing.

**Recommended WF：**

Test configuration is for a single device under free space condition

**Issue 4-2-2: Device positioning guidance**

Proposal 1 (Huawei): CW and reader are placed at the same distance away from the A-IoT device under test.

Proposal 2 (Qualcomm):

* The traditional test system of AC for handheld UE radiated testing can be considered as the starting point for A-IoT device testing.
* The following test setup parameters shall be defined for A-IoT device OTA testing:
	+ DCW2D: distance between CW node and DUT
	+ DMA2D: distance between measurement antenna and DUT
	+ IsoCW2M: Isolation between CW node and measurement antenna



Proposal 3 (CAICT): Reuse TR38.870 positioning guidelines as the baseline for A-IoT FS testing.

Proposal 4 (Ericsson): A-IoT device 1 should be tested while backscattering a CW signal from an external CWT.

**Recommended WF：**

Take proposal 2 as a starting point and further discuss the details.

**Issue 4-2-3: 3D scan**

Proposal 1 (vivo): It is suggested to discuss whether the 3D scan is necessary for device test and the feasibility to verify the device performance on single angle.

Proposal 2 (CAICT): Clarify the applicability of EIRP-like (non-3D) vs. TRP-like metrics (3D scan) in A-IoT OTA testing through further analysis of deployment scenarios, test efficiency, and other related aspects.

**Recommended WF:**

TBA

**Issue 4-2-4: Test antenna location**

Proposal 1 (vivo): Both the Tx/Rx test antenna should locate at the vertical plane of the tag’s long dimension center.

**Recommended WF:**

TBA

**Issue 4-2-5: Test methodology for Tx RF requirements**

Proposal 1 (Qualcomm): Take the following test procedure as the start point for backscattering losing and occupied bandwidth testing.

* Step 1: Conduct the calibration procedure to determine testing antenna gain, CW antenna gain, mismatch between testing/CW antenna to DUT, insertion loss and cable loss, etc.
* Step 2: Determine the power level of RF energy source, duration time of harvesting, and ON-OFF testing pattern to ensure TE can start to transmit CW signal when DUT turns on and then record the backscattering signal from DUT.
* Step 3: Set the target test frequency and transmit power for signal generator and CW signal. The received power at the antenna of DUT shall be Pin. Pin includes both CW and R2D signal. The specific value of Pin is FFS.
* Step 4: Measure and record the backscattering signal level from DUT and calculate the backscattering power level transmitting from DUT antenna, i.e., Pout, based on the calibration data from step 1
* Step 5a (backscattering losing testing): Calculate the ratio of CW power level to D2R signal power (i.e., before and after backscattering) according to the equation: backscattering loss (dB) = Pout – Pin
* Step 5b (occupied bandwidth testing): Determine the bandwidth of backscattering signal

Proposal 2 (vivo): The following two method can be considered to eliminate the influence of CW source during the device emission test:

* Approach 1: Measure the emission power with/without device separately, and calculate the D2R power
* Approach 2: Implement RF shielding to provide enough Tx/Rx isolation

Proposal 3 (Ericsson): For testing TRP, specify CWT power, distance, and angle. Alternatively specify received (at the device antenna port) CW signal level.

**Recommended WF:**

**TBA**

**Issue 4-2-6: Test methodology for Rx RF requirements**

Proposal 1 (Qualcomm): The reference sensitivity of device can be verified by measuring device’s respond timing relationship between R2D and the corresponding D2R transmission with a minimum mean power applied for device antenna. FFS on how to set the side condition.

The following test procedure of reference sensitivity for A-IoT device 1 can be considered as the starting point:

• Step 1: Conduct the calibration procedure to determine testing antenna gain, CW antenna gain, mismatch between testing/CW antenna to DUT, insertion loss and cable loss, etc.

• Step 2: Determine the power level of RF energy source, duration time of harvesting, and ON-OFF testing pattern to ensure TE can start to transmit CW signal when DUT turns on and then record the backscattering signal from DUT.

• Step 3: Set the target test frequency and transmit power for signal generator and CW signal. The transmit power of signal generator shall be set as that the received power at DUT’s antenna is equal to minimum reference sensitivity requirement of device. FSS on the CW signal level.

• Step 4: Determine whether DUT can send the correct response in D2R channel within timing window, e.g., TR2D\_min

Proposal 2 (vivo): The REFSENS definition for tag is not clear and the test procedure may rely on the detailed design in RAN1. The test method for Rx can be started later at least until RAN4 has clear definition

**Recommended WF:**

**TBA**

## Topic 4-3: Others

**Issue 4-3-1: Measurement grid points**

Proposal 1 (Huawei): select one option for measurement points for transmit and receive metrics from the following:

* Option 1: Measurement grid points over hemi sphere in the direction of reader
* Option 2: discrete points in the direction of reader

Proposal 2 (Ericsson): Use a coarse measurement grid of 30 degrees for TRP and 45 degrees for TRS measurement.

**Recommended WF:**

TBA

**Issue 4-3-2: Environmental requirements**

Proposal 1 (Huawei): reuse the environmental requirements from TR38.870 for A-IoT tests.

**Recommended WF:**

TBA

**Issue 4-3-3: Minimum range/ QZ (Quiet Zone) size/QZ calibration**

Proposal 1 (Huawei):

reuse the quiet zone calibration procedure from TR38.870 for A-IoT tests.

reuse the same principle to derive the minimum range length as defined in TR 38.870, and further discuss whether to consider a shorter range length with smaller QZ size.

Proposal 2 (CAICT):

Reuse Quiet Zone/Calibration/Minimum Range Length in TR 38.870 as the baseline, while further investigating system setup and test procedure adaptions for energy charging/discharging management.

**Recommended WF:**

TBA

**Issue 4-3-4: Cross talk impact**

Proposal 2 (Sony): RAN4 shall study impact the due to the cross talk between the testing (receiving) antenna, the cross talk between the CW/energy source antenna for AIoT OTA test.



**Recommended WF:**

TBA

**Issue 4-3-5: MU values**

Proposal 2 (Huawei): use MU values from TR38.870 for terms with similar functionality

**Recommended WF:**

TBA