**3GPP TSG-RAN WG4 Meeting #112-bis R4-2415233**

**Hefei, China, 14th – 18th Oct. 2024**

**Agenda item: 6.21.4**

**Source:** Moderator (CMCC)

**Title:** Topic summary for [112bis][129] FS\_Ambient\_IoT\_solutions\_part1

**Document for:** Information

# Introduction

This summary focuses on the R19 ambient IOT study item under agenda 6.21, 6.21.2.1, 6.21.2.2. The summary in previous meetings are in R4-2405289, R4-2408945 and R4-2412833. The way forward agreed in previous RAN4 meetings are R4-2406714, R4-2410567 and R4-2414304.

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| **TDoc** | **Title** | **Source** |
| R4-2415001 | Collection of calibration data for A-IoT | CMCC |
| **[R4-2415097](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415097.zip)** | Discuss on AIoT R2D LLS in RAN4 | CATT |
| [**R4-2415449**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415449.zip)**（move to [130]）** | A-IoT general overview | Ericsson |
| **[R4-2414963](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2414963.zip)** | Discussion on A-IoT deployment scenarios and spectrum usage | Huawei, HiSilicon |
| R4-2414995 | Deployment scenario and spectrum usage | CMCC |
| [**R4-2415305**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415305.zip) | Discussion on AIoT deployment scenarios and spectrum usage | Qualcomm Incorporated |
| [**R4-2415448**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415448.zip) | A-IoT deployment scenario and spectrum usage | Ericsson |
| [**R4-2415763**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415763.zip) | Discussion on the impact of CW node | vivo |
| [**R4-2414996**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2414996.zip) | Discussion on A-IoT co-existence evaluation | CMCC |
| R4-2415052 | Simulation results for Ambient-IoT Co-existence study | Xiaomi |
| R4-2415082 | Co-existence evaluation results for Ambient IoT in NR | CATT |
| [**R4-2415098**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415098.zip) | Discussion on co-existence simulation parameters | CATT |
| [**R4-2415306**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415306.zip) | Discussion on Ambient IoT Coexistence Evaluations | Qualcomm Incorporated |
| [**R4-2415453**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415453.zip) | Coexisting study simulation assumptions and initial results | Ericsson |
| [**R4-2415580**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415580.zip) | Coexistence evaluation on D1T1 deployment scenario | Sony |
| [**R4-2415596**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415596.zip) | on co-existence evaluations | OPPO |
| [**R4-2415608**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415608.zip) | Discussion on co-existence evaluation results for Ambient IoT and NR | Spreadtrum Communications |
| [**R4-2415764**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2415764.zip) | Discussion on the co-existence for D2T2 | vivo |
| [**R4-2416229**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2416229.zip) | Discussion on Co-existence evaluations | ZTE Corporation, Sanechips |
| [**R4-2416230**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2416230.zip) | The calibration results for A-IoT evaluations | ZTE Corporation, Sanechips |
| [**R4-2416301**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2416301.zip) | On co-existence assumptions | Samsung |
| R4-2416355 | Collection of simulation results for Ambient-IoT co-existence study | Huawei, HiSilicon |
| [**R4-2416356**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2416356.zip) | TP to TR38.769: Co-existence simulation | Huawei, HiSilicon |

# TP

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| **TDoc** | **Title** | **Source** |
| [**R4-2416356**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112bis/Docs/R4-2416356.zip) | TP to TR38.769: Co-existence simulation | Huawei, HiSilicon |

**Issue 1-1: TP**

Recommended WF:

Agree the TP as template for the summary of co-existence evaluation.

# Deployment scenarios and spectrum usage

## Topic 2-1: Deployment scenario

**Issue 2-1-1: deployment scenarios for D1T1**

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| **Agreement in RAN4#110bis:****Issue 2-1-1: deployment scenarios for D1T1**Option 1-1: Legacy NR gNB are outdoor macro gNB while AIoT reader/CW/devices are all indoors. Legacy NR UE is only allowed outdoors.Option 1-2: Legacy NR gNB are outdoor macro gNB while AIoT reader/CW/devices are all indoors. Legacy NR UE is indoor accessing to outdoor NR marco gNBOption 2-1: Legacy NR gNB are co-located with AIoT reader and CW. All of NR and AIoT BS/UE/Reader/Device/CW are indoors. AIoT reader /CW and Legacy gNB share same hardwareOption 2-2: Legacy NR gNB are co-located with AIoT reader and CW. All of NR and AIoT BS/UE/Reader/Device/CW are indoors. AIoT reader /CW and Legacy NR gNB do not share same hardware. (less limitation on the power boosting)**Agreement:*** RAN4 to first evaluate co-existence for deployment scenario of option 1-1 and 1-2, and further study option 2-1 and 2-2.

**Issue 2-3-2: Priorities of spectrum deployment mode for co-existence evaluation****Agreement:*** Prioritize the following spectrum deployment mode for RAN4 co-existence evaluation
	+ A-IoT is located within a NR transmission bandwidth configuration
	+ A-IoT which is operating indoor shares in-band spectrum with outdoor macro BS

**Agreement in RAN4#111:** * Consider only adjacent RB/channel co-existence evaluation for in-band deployment scenario for NR and AIOT
* Encourage companies to provide the simulation results for option 1-1 and 1-2
	+ FFS on co-site scenario (option 2-1 and 2-2)

瀑布图  低可信度描述已自动生成**Agreement in RAN4#112:*** Feasibility of option 2-1/2-2 for device 1 and 2a can be evaluated with LLS. Parameters for LLS are based on company report.
	+ Encourage companies to provide the co-existence simulation results.
 |

**Proposal in RAN4#112bis:**

Proposal 1 (Huawei, R4-2414963): It is difficult to implement Option 2-1 and Option 2-2 due to the significant difference in PSD and interference.

* In this scenario, there may be a significant sensitivity difference between A-IoT devices (specifically Device 1 and Device 2a) and legacy NR UEs. Interference between indoor NR UEs and indoor A-IoT BS may be problematic due to mutual blocking. When the interference source is the A-IoT micro-BS transmitter, and the victim is the indoor NR UE receiver, the interference signal from A-IoT BS transmitter can reach levels about -36dBm.However, the blocking level for the NR UE receiver is -56dBm, which means that some NR UE receivers may be blocked by the A-IoT micro-BS transmitting signal. Conversely, a few NR UE receivers that receive strong NR signals and are not blocked by the A-IoT may interfere with the A-IoT micro-BS receiver.

Proposal 2 (Ericsson, R4-2415448): Option 2-1/2-2 is not possible for A-IoT R2D reception when co-located NR BS transmit equal or higher PSD than A-IoT BS with certain amount.

* The PSD difference between the NR signal and A-IoT signal is simulated with a range of 0 dB to -12 dB. It can be observed that if the NR signal PSD is greater than the -11 dB, R2D reception will not reach even the 10% BLER.

**Recommended WF:**

Following last meeting agreement, feasibility of option 2-1/2-2 can be evaluated. Further discuss on how to capture the evaluation in TR.

Ericsson: We have provided the link level simulation to show PSD level between co-located BS and A-IoT is critical for feasibility. If other companies need more time to simulate, we can further discussion.

Samsung: The interference level would be OK. We can provide the link level simulation later.

Moderator: we can further discuss how to capture the feasibility evaluation in TR.

## Topic 2-2: Spectrum usage

**Issue 2-2-1: Spectrum usage for R2D in D1T1**

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| **Agreement in RAN4#110bis:*** FFS on whether to prioritize FDD DL spectrum for R2D for D1T1 for co-existence evaluation.

**Agreement in RAN4#111:** * Use FDD DL as starting point for co-existence evaluation for R2D in D1T1
	+ FFS on FDD UL spectrum.

**Agreement in RAN4#112:** * Use FDD DL as baseline for co-existence evaluation for R2D in D1T1, FDD UL can be considered as optional
 |

**Proposal in RAN4#112bis:**

Proposal 1 (QC, R4-2415305) RAN4 should consider using UL spectrum for R2D as a potential deployment solution to solve the interference coexistence issue in D1T1 with legacy UE indoor.

**Recommended WF:**

FDD UL is already agreed for co-existence evaluation as optional. No more discussion is needed.

Qualcomm: Last meeting we had proposal to consider UL spectrum as optional. In this meeting we show the simulation results with UL spectrum which can solve the interference coexistence issue in D1T1 with legacy UE indoor.

Sony: From co-existence perspective, we have no further update. Maybe we can agree that to solve the issue some UL spectrum can be considered.

CMCC: it is too earlier to conclude.

# Evaluation methodology and cases

## Topic 3-1: LLS consideration

**Issue 3-1-1: LLS assumption**

Proposal 1(vivo, R4-2415764):

AWGN is used in the link level simulation to derive the SINR threshold for R2D and D2R.

The baseline LLS assumption should be aligned in the group before the discussion of the outage probability.

Proposal 2(CATT, R4-2415097): Companies to align the following concept for passive device R2D LLS.

* What processing modules are included in the LLS link.
* ED input SNR and ED output SNR concept and which SNR is used to derive the SNR threshold.

RAN4 should discuss if the ED and comparator model need to be aligned between the companies.

**Recommended WF:**

Discuss whether and how to align the LLS assumption and device assumption.

Moderator: in RAN4 we can use AWGN channel for RAN4 evaluation.

Huawei: Generally AWGN channel is OK. RAN4 now reuses RAN1 assumption. It is difficult to align between RAN1 and RAN4 since the parameters is too many. But fading channel is widely used in RAN4 table and considering the limited time, we need further discuss whether AWGN channel is used.

Sony: What SNR are we talking about, SNR in baseband or SNR at antenna?

Huawei: We use SNR at antenna.

Qualcomm: From co-existence point of view, RAN4 uses fading channel. If we want to consider link level results, we consider fading channel.

Ericsson: we also consider fading channel to be used. For SNR, we should follow the demodulation definition which is at antenna. There is no need to align the simulation assumption. RAN1 did not reach consensus.

Vivo: We are also fine to use fading channel. For RAN4 we already have co-existence evaluation.

CATT: in our view, the aligned assumption is needed. AWGN should be basis for co-existence.

Moderator: in SI, it is challenging to align. We can do offline and check if we can converge on the values.

**Issue 3-1-2: R2D SINR @10% BLER**

Proposal 1 (Huawei, R4-2414963): Assuming BLER=10%, the Input SNR for a RF envelope detector is required to be around [4] dB, given that the RF BW=10MHz.

Proposal 2 (Samsung, R4-2416356): For R2D BLER 10%, the CNR target is around 1dB for 0 information bits, and CNR of around 3dB for 96 information bits.

Proposal 1 (Ericsson, R4-2415453)

* SNR threshold = 17.8 dB is used for outage observation without NR signal
* Further study is needed to see how to use different SNR threshold when NR signal is present.

**Recommended WF:**

Discuss issue 3-1-1 first.

**Issue 3-1-3: D2R SINR @10% BLER**

Proposal 2 (Samsung, R4-2416356): For D2R BLER 10%, the SINR target would be within the range of -10 to -5 dB.

**Recommended WF:**

Discuss issue 3-1-1 first.

## Topic 3-2: Performance metric and SINR definition

**Issue 3-2-1: Performance metric for AIOT**

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| **Agreement in RAN4#110bis:*** For NR system, use 5% throughput loss as performance metric as legacy.
* For AIOT system, including reader, device, intermediate UE, further discuss the performance metric:
	+ Option 1: [10%] BLER, [Rx power]
	+ Option 2: SINR degradation
	+ Other options are precluded

**Agreement in RAN4#111:** * Use SINR for calibration purpose
* FFS on performance metric for co-existence evaluation and requirements definition.

**Agreement in RAN4#112:**For inter-system interference (between AIOT and NR):* If SINR degradation is smaller than or equal to [1]dB, it can be considered that inter-system interference is negligible.
* If SINR degradation is lager than [1]dB, consider following criteria:
	+ Outage percentage consider SINR level with [10%] BLER
	+ FFS on the outage percentage
* Note: For SINR degradation, SINR refers to the 5% and 50% CDF SINR

For intra-system interference (between AIOT and AIOT):* + Outage percentage consider SINR level with [10%] BLER
	+ FFS on the outage percentage
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**Proposal in RAN4#112:**

Proposal 1 (Ericsson, R4-2415453): Baseline outage percentile is 20% and needs improvement of coexisting simulation assumption to reduce the outage percentile.

**Recommended WF:**

Discuss issue 3-1-1 first.

**Issue 3-2-2: SINR definition for D2R**

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| **Agreement in RAN4#111:**Do not consider CW interference for calibration purpose for D1T1-A2 and D2T2-A2FFS on how to consider CW cancellation capability in formal simulation**Agreement in RAN4#112:*** SINR includes CW interference is used as the baseline reference for co-existence evaluation for CW reader.

$$baseline SINR=\frac{received wanted signal power}{\left(noise + intra\\_system interference\right)\_{within total receiver bandwidth}+\left(residual CW interference after cancellation\right)\_{in linear scale}}$$* SINR is calculated as total power ratio:

$$SINR=\frac{received wanted signal power}{\left(noise + intra\\_system interference + inter\\_system interference\right)\_{within total receiver bandwidth}+\left(residual CW interference after cancellation\right)\_{in linear scale}}$$ |

**Proposal in RAN4#112bis:**

Proposal 1 (QC, R4-2415306):

RAN4 should account for phase noise in CW outside topology and baseline SINR can be calculated by:

$$baseline SINR for CW outside=\frac{received wanted signal power}{\left(noise + intra\_{systeminterference}+phase noise\right)\_{within total receiver bandwidth}+\left(residual CW interference after cancellation\right)\_{in linear scale}}$$

Phase noise is YdBm/Hz, and Y is related to the received CW power level at the reader.

Proposal 2 (Ericsson, R4-2415453): Use SNR degradation of 1 dB, 3 dB and 10 dB in coexisting study to evaluate the CW cancellation impact for CW inside topology A2.

**Recommended WF:**

More discussion is needed.

Huawei: Phase noise is not necessary. Phase noise impact is included in the residual CW interference after calculation.

CATT: in which metric the phase noise to be added?

Ericsson: in our paper, for CW cancellation, we identify CW impact on the hardware and also the leakage power input to LNA and linearity of receiver. This two parameters will decide the MSD of the receiver.

ZTE: regarding proposal 2, we support. SINR is very challenging. Regarding Qualcomm proposal, we need more offline. Cancellation can handle the phase noise.

Qualcomm: For noise phase, we consider the additional noise phase, which is before the CW cancellation, and which is not coherent.

Ericsson: Close-in phase noise from CW transmission may compete with that backscattering signal because the frequency offset turn from backscattering signal is very narrow.

ZTE: There is a lot of ways to handle the phase noise signals. Different cancellation can be used.

**Issue 3-2-3: SINR definition for R2D**

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| **Agreement in RAN4#111:**SINR for R2D for calibration purposes* signal power of device to the noise and interference within 10MHz
	+ Assume interference NR BW is 10MHz
* FFS on BB LPF

**Agreement in RAN4#112:** * signal power of device to the noise and interference within 10MHz is baseline assumption
* Consider [180KHz] noise and interference bandwidth after BB LPF as optional
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**Proposal in RAN4#112bis:**

Proposal 1 (Ericsson: R4-2415453): The noise bandwidth should not be assumed as 10MHz or 180kHz for device 1/2a.

**Recommended WF:**

More discussion is needed.

Ericsson: there is open issue how to model RFED in R2D receiving. We have simulate with perfect 180KHz. After link level simulation, it seems not perfect. It is related to NR signal bandwidth and PSD difference of turned signal and multi signals. We should further discuss how to model this according to link level simulation.

Sony: this issue is related to later issue how to model R2D receiver.

CATT: We propose to introduce RFED input SINR and RFED output SINR.

Moderator: we have the issue related later.

## Topic 3-3: CW considerations

**Issue 3-3-1: CW cancellation capability**

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| **Agreement in RAN4#111:**Do not consider CW interference for calibration purpose for D1T1-A2 and D2T2-A2FFS on how to consider CW cancellation capability in formal simulation**Agreement in RAN4#112:*** Companies to report the CW cancellation capability used for co-existence evaluation, CW cancellation capability for inside topology and outside topology can be different.
	+ total interference cancellation capability = spatial isolation + RF cancellation + digital cancellation
	+ CW transmission impact on the received SINR, e.g. degradation
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Proposal 1 (Ericsson, R4-2415453): Use SNR degradation of 1 dB, 3 dB and 10 dB in coexisting study to evaluate the CW cancellation impact for CW inside topology A2.

**Recommended WF:**

More discussion is needed.

## Topic 3-4: Evaluation cases

**Issue 3-4-1: Simplification of evaluation cases**

Proposal 1 (Huawei, R4-2414963): If D1T1-A2 passes the co-existence evaluation, then it can be assumed that D1T1-A1 with the same spectrum usage will also perform well.

**Recommended WF:**

Agree proposal 1 as the principle and further consider how to capture in the TR.

Qualcomm: for A1, there is also similar phase noise issue due to non-sync or non-coherent signals. We need check whether the conclusion will be affected.

Ericsson: There are fundamental difference. For A2 CW is collocated. For A1 it is outside topology.

ZTE: We can discuss D1T1-A2 first and then further discuss D1T1-A1.

Moderator: the outside topology, D1T1-A1 is non-collocated indoor. We do not list D1T1-A1 in the co-existence study. That is why Huawei propose it.

# Evaluation parameters and results

## Topic 4-1: Adjacent RB Tx and Rx characteristics

**Issue 4-1-1: A-IOT reader and NR BS**

**Proposals in RAN4#112bis:**

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|  | In-band |
| Tx | Rx |
| NR UE/A-IOT Intermediate UE | **Last meeting agreement:**Legacy UE IBE**Proposal in RAN4#112bis:**Proposal 1 (QC, R4-2415306): For R2D to NR UL, the following IBE and leakage model is considered:* EVM: follow SINR or fixed modulation, e.g., QPSK
* NRB = 51
* No Guard band: IBE is 18dB for UE2 and UE3, IBE is 42dB for UE1 (see Figure 1)
* With Guard band: IBE is IBE with xRB offset, for UE2 and UE3, IBE is 43 for UE1 (see Figure 1)

Proposal 2 (QC, R4-2415306): For NR UL to D2R, the following IBE and leakage model is considered:* EVM: need a reference for OOK
* NRB = 51
	+ No Guard band: IBE is 18dB
	+ With Guard band: IBE is IBE with xRB offset

Proposal 3 (vivo, R4-2415764): Further study the feasible ACLR assumption for intermediate UE. | **Last meeting agreement:**In-band A-IOT signal interference to NR is not considered when calculating SINR. Companies to check the interference caused by non-orthogonal A-IOT signal**Proposal in RAN4#112bis:**Proposal 1 (CATT, R4-2415098): It is proposed that UE vendors to check NR UE Rx FFT window choice implementation to double check AIoT DL signal’s non-orthogonal impact when AIoT reader is deployed nearby but NR BS is very far.Proposal 2 (CATT, R4-2415098): Use -30 dB 1 RB scaled emission level to model the backscattering based UL signal non-orthogonal impact to NR UE Rx.Proposal 3 (Ericsson, R4-2415453): **No need to consider inter-numerology interference as current coexisting assumes the same SCS between NR BS and A-IoT BS.**Proposal 4 (Ericsson, R4-2415453): **Check if network has 30kHz SCS deployment in n8 and decide if inter-numerology should be considered in coexisting simulation scope.**Proposal 5: (QC, R4-2415306): The NR UE blocking issue and corresponding maximum interference power need further study in RAN4.Ericsson: in the coexistence simulation, we assume the same SCS in A-IoT BS and NR BS. There is possibility to deploy 30KHz SCS in NR BS. We need check if we need consider this case.ZTE: 15KHz SCS is always. We do not need consider 30KHz.CMCC: for FDD NR system, 15KHz is used rather than 30KHz.Huawei: Agree with ZTE and CMCC.Ericsson: we can document it in the agreement that only 15KHz SCS is used.Qualcomm: consider blocking issue is needed.Moderator: should we discuss it in the requirement thread?Qualcomm: based on the values, we can conclude whether it can be coexisted with NR or not. |
| NR BS | **Last meeting agreement:**Option 1: 30dBcOption 2: 17dBcAgreement: * In addition to Option 1 30dBc and Option 2 17 dBc, the new Option 3 with new value is added.

Companies to check the leakage of legacy NR BS.**Proposal in RAN4#112bis:**Proposal 1 (CATT, R4-2415098): * Use ACLR approach to model NR BS in-band emission for co-existence simulation.
* NR BS ACLR for 1 blank RsB is assumed as 12 dB when NR BS is transmitted full RB except this blank RB.

CATT: we are fine with either replace one value or add new value.Proposal 2 (Ericsson, R4-2415453): * The inband leakage from iFFT modulation should be 15 dB considering additional RF impairment
* No need to consider inter-numerology interference as current coexisting assumes the same SCS between NR BS and A-IoT BS.
* Check if network has 30kHz SCS deployment in n8 and decide if inter-numerology should be considered in coexisting simulation scope.

Proposal 3 (ZTE, R4-2416229): use the in-band leakage as 17dBc for coexistence sharing study. | **Last meeting agreement:**In-band A-IOT signal interference to NR is not considered when calculating SINR. Companies to check the interference caused by non-orthogonal A-IOT signal**Proposal in RAN4#112bis:**Proposal 1 (CATT, R4-2415098): The non-orthogonal impact for AIoT DL signal to NR BS Rx is not so critical so it can be ignored in the co-existence simulation.Proposal 2 (CATT, R4-2415098): Use -30 dB 1 RB scaled emission level to model the backscattering based UL signal non-orthogonal impact to NR BS Rx.Proposal 3 (Ericsson, R4-2415453): **No need to consider inter-numerology interference as current coexisting assumes the same SCS between NR BS and A-IoT BS.**Proposal 4 (Ericsson, R4-2415453): **Check if network has 30kHz SCS deployment in n8 and decide if inter-numerology should be considered in coexisting simulation scope.** |
| A-IOT BS | **Last meeting agreement:**ACLR of legacy NB -IOT gNB (i.e. ACLR1:40dBc，ACLR2:50dBc)**Proposal in RAN4#112bis:**Proposal 1 (ZTE, R4-2416229): for A-IoT BS ACLR requirement, propose to define it as 45dBc;ZTE: in current the system bandwidth in RAN1 is under discussions. | **Last meeting agreement:**ACS of legacy gNB**Proposal in RAN4#112bis:**Proposal 1 (ZTE, R4-2416229): need some further discussion on A-IoT BS ACS requirement. |

**Recommended WF:**

More discussion is needed.

**Issue 4-1-2: CW unwanted emissions**

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| **Agreement in RAN4#112:**Discuss whether and how to model the CW unwanted emission. |

**Proposal in RAN4#112bis:**

Proposal 1 (CATT, R4-2415098): CW unwanted emission is not necessary to be considered and modeled in the co-existence simulation because the phase noise contribution to the total noise is negligible.

Proposal 2 (vivo, R4-2415763): To reduce the impact of CW, the CW in AIoT system should be orthogonal with NR subcarrier.

**Recommended WF:**

Assume no unwanted emission and orthogonal with NR carrier for CW node for co-existence evaluation.

**CATT: this is aligned with our proposal.**

**Ericsson: This signal should be sent as single tone. Maybe the local OS is used. We would like to keep unwanted emission open.**

**Moderator: keep it as baseline.**

**Ericsson: what the orthogonal means?**

**ZTE: The single tone CW is NR signal. The phase noise is not orthogonal. Need to discuss how to cancel the CW signals.**

**Vivo: we find some published paper to do evaluation how CW signaling impacts the NR system. If it is orthogonal, the impact is very low.**

**Huawei: we have other topic about CW cancellation. There we can discuss blocking issue and noise phase. For co-exisetnce, we can assume no CW emission.**

**Issue 4-1-3: Rx for device 1 and 2a**

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| **Agreement in RAN4#111:**Assume no frequency selectivity for co-existence evaluation for calibration purposes for device 1 and 2a.**Agreement in RAN4#112:*** Alt-1: Assume no frequency selectivity
* Alt-2:

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| **SINR** | **R2D with LPF** |
| Interference from NR | Frequency selectivity: [7.5 dB] |
| Noise bandwidth | [180kHz] |
| $$SINR\_{R2D\\_with\\_LPF}=\frac{Wanted\\_S\_{R2D\\_180kHz}}{NoiseFloor\_{ 180kHz}+(Interference\_{NR\_{10MHz}}/LPF\\_Selectivity\_{linear})}$$ |

* Alt-3:

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| **For R2D receiver with LPF** |
| **RF BW** | 10MHz |
| **BB BW** | [180kHz] |
| **SINRi** (linear, not dB) | Input SINR at the antenna connector with noise/interferencde BW=RF BW |
| **SINRo** (linear, not dB) | Output SINR after BB LPF assuming downconverted noise/interference BW=BB BW |
| $$SINR\_{o}=\frac{SINR\_{i}^{2}}{\left(8\*SINR\_{i}+4\right)}\*\frac{BW\_{RF}}{BW\_{BB}}$$ |

* Alt-4: other LLS assumptions are not excluded
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**Proposals in RAN4#112:**

Proposal 1 (Sony, R4-2415580):

* the effect of LPF in the R2D receiver shall be taken into account for the coexistence simulation.
* considering the complication of modeling the LPF and the necessity of simulating the case scenario in a coexistence study, no LPF results can be taken as baseline results. If any coexistence cases are problematic, RAN4 can further discuss if those cases can be resolved by taking into account the LPF**.**

Proposal 2 (Ericsson, R4-2415453): Further study how to consider the LLS simulation in coexisting study.

**Recommended WF:**

Discuss whether no frequency selectivity results is taken as baseline.

**Sony: we had agreed previously when we discuss.**

## Topic 4-2: General parameters and layout

**Issue 4-2-1: Active rate of reader for D1T1**

|  |
| --- |
| **Agreement in RAN4#112:*** Minimum distance between active readers: 60m as baseline, other values can be reported by other companies.

- 2 readers are activated in one drop as baseline |

**Proposal in RAN4#112bis:**

Proposal 1 (Sony, R4-2415580): activating only a single reader can significantly improve the baseline SINR. the number of simultaneously active readers shall ensure the baseline SINR meets the target value.

Proposal 2 (Ericsson, R4-2415453): Active only A-IoT BS at a time can have 0 percentage outage.

**Recommended WF:**

Keep 2 readers activated in one drop as baseline.

**Agreement:**

* Keep 2 readers activated in one drop as baseline.

**Issue 4-2-2: Indoor UE percentage for scenario option 1-2**

|  |
| --- |
| **Agreements in RAN4#111:**For scenario option 1-2, uniformly distributed, 80% indoor, 20% outdoor**Agreements in RAN4#112:*** Option 1: 10%
* Option 2: 100%
 |

**Proposals in RAN4#112bis:**

Proposal 1 (Sony, R4-2415580):

* the SINR degradation on AIoT system due to NR UL, and the SINR degradation on NR DL due to the AIoT system are significant when the NR UE percentage is 100% indoor.
* Some mechanisms to coordinate multiple readers to be active simultaneously may need to be considered.

Proposal 2 (Spreadtrum, R4-2415608): Related solutions for co-existence between A-IoT and NR for in-band deployment need to be considered when NR UE is indoor.

**Recommended WF:**

More discussion is needed on how to consider some mechanisms to reduce the interference when NR UE is indoor.

**Sony: we have no concrete proposal of solution at this stage. We are OK with WF.**

**OPPO: Based on our simulation reults, we support Sony proposal and further check the mechism.**

**Qulacomm: we have similar proposal as the previous meeting and support proposal 1. We can capture soluton if needed.**

**Huawei: We can do it in WI.**

**Moderator: the intention is not to change the method for co-existence evaluation. We can document the potential mechanism. No need of agreement.**

**Issue 4-2-2: device access control algorithms**

Proposal 1 (QC, R4-2415305): The device access control algorithms should be studied and confirmed to ensure that coexistence simulations match AIoT real deployments.

* It had been observed that if a more advanced access control algorithm is considered when a device accesses a reader, such as allowing the device to access a reader that is closer to it at a certain time in the future, the performance of the system can be improved

**Recommended WF:**

The advanced access control algorithm can be considered as optional for co-existence evaluation by company report.

Qualcomm: “advanced access control algorithm”, we had no common understanding what access control is used in the simulation. We suggest to capture this algorithm used in companies’ simulation in the TR.

## Topic 4-6: Evaluation Conclusion

**Moderator note:**

Following table summarizes the observation of evaluation from companies’ contributions.

For the case that more than 1 company provide similar observations/results, I try to provide tentative co-existence conclusion. For the other cases, i.e. no consensus observations or only 1 company provide results, it is recommended for further discussion and wait for more results. The table can be updated during the meeting after collecting more results.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **deployment scenario and topology** | **spectrum** | **Evaluation case No.** | **(Aggressor -> Victim)** | **Summary of observations from companies** | **Tentative Co-existence conclusion** |
|  |
| **1-1** | **D1T1-A2- legacy UE only outdoor** | R2D: DLCW2D and D2R: DL | a | Device->NR DL | CMCC (R4-2414996): No throughput degradationQC (R4-2415306): MarginalSpreadtrum (R4-2415608): no co-existence impactZTE (R4-2416229): No throughput degradationSony (R4-2415580): it is feasible from co-existence aspectEricsson (R4-2415453): No significant impact on victim system  | No NR DL throughput degradation for both average throughput and cell edge throughput is observed |  |
| b | NR DL->reader | CMCC (R4-2414996):SINR degradation is less than 1dB. Device 1 outage percentage consider SINR level with 10% BLER is 16%. Device 2a outage percentage consider SINR level with 10% BLER is 7%QC (R4-2415306): SINR degradation @5-ile is 2dB, 50-ile is 0.8dB withSpreadtrum (R4-2415608): no co-existence impactZTE (R4-2416229): 0dB SINR degradation @50%, 3dB SINR degradation @5% Sony (R4-2415580): it is feasible from co-existence aspectEricsson (R4-2415453): Significant impact pending further understanding of LLS | TBA |  |
| c | Reader->NR DL | CMCC (R4-2414996): No throughput degradationQC (R4-2415306): MarginalSpreadtrum (R4-2415608): no co-existence impact \ZTE (R4-2416229): No throughput degradationSony (R4-2415580): it is feasible from co-existence aspectEricsson (R4-2415453): No significant impact on victim system | No NR DL throughput degradation for both average throughput and cell edge throughput is observed |  |
| d | NR DL->device | CMCC (R4-2414996): SINR degradation is less than 1dB.Outage percentage consider SINR level with 10% BLER is 0% for both device 1 and 2a.QC (R4-2415306): SINR degradation @50-ile is 0.4dBSpreadtrum (R4-2415608): no co-existence impactZTE (R4-2416229): SINR degradation is less than 1dB.Sony (R4-2415580): it is feasible from co-existence aspectEricsson (R4-2415453): Significant impact pending further understanding of LLS | SINR degradation is less than 1dB. TBD on the outage percentage |  |
| **1-2** | **D1T1-A2-legacy UE indoor** | R2D: DLCW2D and D2R: DL | a | Device->NR DL | CMCC (R4-2414996): No throughput degradationQC (R4-2415306): MarginalSpreadtrum (R4-2415608): no co-existence impact ZTE (R4-2416229): No throughput degradationSony (R4-2415580): SINR degradation is significant when NR UE is 100% indoorEricsson (R4-2415453): No significant impact on victim system with 10% NR UE indoor | No NR DL throughput degradation for both average throughput and cell edge throughput is observed |  |
| b | NR DL->reader | CMCC (R4-2414996): SINR degradation is less than 1dB. Device 1 outage percentage consider SINR level with 10% BLER is 16%. Device 2a outage percentage consider SINR level with 10% BLER is 7%QC (R4-2415306): SINR degradation @5-ile is 2dB, 50-ile is 0.8dB with 140dB CW cancellation capabilitySpreadtrum (R4-2415608): no co-existence impactZTE (R4-2416229): 0dB SINR degradation @50%, 3dB SINR degradation @5%Ericsson (R4-2415453): Significant impact pending further understanding of LLS | TBA |  |
| c | Reader->NR DL | CMCC (R4-2414996): with 10% indoor UE, about 10% throughput degradation for average throughput is observed, about 70% throughput degradation for cell edge throughput is observedQC (R4-2415306): With 100% indoor UE, interference is too high. Need to check the NR UE Blocking issueSpreadtrum (R4-2415608): when 10% indoor UE, no co-existence impact between A-IoT and NR when Legacy UE is only outdoor. When 100% legacy indoor UE, there is severe co-existence impact between A-IoT and NR, The SINR degradation is much higher than 1dB, and the throughput loss is 82.9%@50%ZTE (R4-2416229): when 100% indoor UE, 3.4% average throughput loss, 13.4 cell edge throughput lossSony (R4-2415580): SINR degradation is significant when NR UE is 100% indoorEricsson (R4-2415453): No significant impact on victim system with 10% NR UE indoor | NR DL throughput degradation for both average throughput and cell edge throughput is observed. *Note: TBD on the throughput degradation level* |  |
| d | NR DL->device | CMCC (R4-2414996): SINR degradation is less than 1dB. Outage percentage consider SINR level with 10% BLER is 0% for both device 1 and 2a.QC (R4-2415306): SINR degradation @50-ile is 0.4dBSpreadtrum (R4-2415608): no co-existence impactZTE (R4-2416229): SINR degradation is less than 1dBEricsson (R4-2415453): Significant impact pending further understanding of LLS | SINR degradation is less than 1dB.TBD on the outage percentage. |  |
| **2-1** | **D1T1-B-legacy UE only outdoor** | R2D: DLCW2D and D2R: UL | e | Device->NR UL | CMCC (R4-2414996): No throughput degradation Spreadtrum (R4-2415608): no co-existence impactZTE (R4-2416229): less than 1% throughput lossEricsson (R4-2415453): No significant impact on victim system | NR UL throughput degradation for both average throughput and cell edge throughput is observed.  |  |
| f | NR UL->reader | CMCC (R4-2414996): SINR degradation is less than 1dB. Outage percentage consider SINR level with 10% BLER is 3% for device 1 and 2% for device 2aSpreadtrum (R4-2415608): no co-existence impactZTE (R4-2416229): 6.34dB SINR degradation @50%, 7.59 SINR degradation @5%Ericsson (R4-2415453): No significant impact on victim system | TBA |  |
| c | Reader->NR DL | CMCC (R4-2414996): No throughput degradation Spreadtrum (R4-2415608): no co-existence impactZTE (R4-2416229): no throughput degradationEricsson (R4-2415453): No significant impact on victim system | NR DL throughput degradation for both average throughput and cell edge throughput is observed.  |  |
| d | NR DL->device | CMCC (R4-2414996): SINR degradation is less than 1dB. Outage percentage consider SINR level with 10% BLER is 0% for both device 1 and 2aSpreadtrum (R4-2415608): no co-existence impactZTE (R4-2416229): SINR degradation is less than 1dBEricsson (R4-2415453): Significant impact pending further understanding of LLS | SINR degradation is less than 1dB.TBD on the outage percentage. |  |
| **2-2** | **D1T1-B-legacy UE indoor** | R2D: DLCW2D and D2R: UL | e | Device->NR UL | CMCC (R4-2414996): No throughput degradation for NR system for average throughput and cell edge throughputZTE (R4-2416229): less than 1dB throughput lossEricsson (R4-2415453): No significant impact on victim system | NR UL throughput degradation for both average throughput and cell edge throughput is observed.  |  |
| f | NR UL->reader | CMCC (R4-2414996): SINR degradation is 13dB for cell edge and 4dB for averageOutage percentage consider SINR level with 10% BLER is 21% for device 1 and 17% for device 2aSpreadtrum (R4-2415608): when 10% Legacy UE is indoor. The SINR degradation is much higher than 1dB. And the outage percentage is 88% consider SINR level with 10% BLER.there is more severe co-existence impact between A-IoT and NR when 100% Legacy UE is indoor compared to10% legacy UE is indoor. The SINR degradation is much higher than 1dB.ZTE (R4-2416229): 36.37dB SINR degradation @50%, 46.82dB SINR degradation @5%Ericsson (R4-2415453): No significant impact on victim system | SINR degradation is larger than 1dB.TBD on the SINR degradation value.TBD on the outage percentage |  |
| c | Reader->NR DL | CMCC (R4-2414996): when 10% indoor UE, about 10% throughput degradation for average throughput is observed, about 70% throughput degradation for cell edge throughput is observedSpreadtrum (R4-2415608): The SINR degradation is much higher than 1dBZTE (R4-2416229): when 100% indoor UE, 13.4% cell edge throughput loss, 3.4% average throughput lossEricsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor | NR DL throughput degradation for both average throughput and cell edge throughput is observed. *Note: TBD on the throughput degradation level* |  |
| d | NR DL->device | CMCC (R4-2414996): SINR degradation is less than 1dB. Outage percentage consider SINR level with 10% BLER is 0% for both device 1 and 2aZTE (R4-2416229): SINR degradation is less than 1dB.Ericsson (R4-2415453): Significant impact pending further understanding of LLS | SINR degradation is less than 1dB.TBD on the outage percentage. |  |
| **3 (O)** | **D1T1-A2-legacy UE indoor** | R2D: ULCW2D and D2R: DL | a | Device->NR DL | QC(R4-2415306): Marginal |  |  |
| b | NR DL->reader | QC(R4-2415306): SINR degradation @5-ile is 2dB, 50-ile is 0.8dB with 140dB CW cancellation capabilityEricsson (R4-2415453): Significant impact pending further understanding of LLS |  |  |
| g | Reader->NR UL | QC(R4-2415306): 8.73% mean T-put loss, cell edge T-put is N/A due to outageEricsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor |  |  |
| h | NR UL->device | QC(R4-2415306): 1.78dB for 5-ile SINR degradation, 1.22dB for 50-ile SINR degradation Ericsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor |  |  |
| **4 (O)** | **D1T1-B-legacy UE indoor** | R2D: ULCW2D and D2R: UL | e | Device->NR UL | Ericsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor |  |  |
| f | NR UL->reader | Ericsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor |  |  |
| g | Reader->NR UL | Ericsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor |  |  |
| h | NR UL->device | Ericsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor |  |  |
| **5-1** | **D2T2-A2-legacy UE only outdoor** | R2D: ULCW2D and D2R: UL | e | Device->NR UL | CMCC (R4-2414996): No throughput degradation for NR system for average throughput and cell edge throughputQC(R4-2415306): Marginalvivo (R4-2415764): impact is ignorableEricsson (R4-2415453): No significant impact on victim system | No NR UL throughput degradation for both average throughput and cell edge throughput is observed |  |
| f | NR UL->reader | CMCC (R4-2414996): SINR degradation is less than 1dB. Outage percentage consider SINR level with 10% BLER is 4% for device 1 and 3% for device 2aQC(R4-2415306): SINR degradation is marginal with 130dB CW cancellation capability.OPPO (R4-2415596): 0.01 dB SINR degradation@5%, 0.7 dB SINR degradation @50%vivo (R4-2415764): impact is ignorableEricsson (R4-2415453): No significant impact on victim system | SINR degradation is less than 1dB.TBD on the outage percentage. |  |
| g | Reader->NR UL | CMCC (R4-2414996): about 6% throughput degradation is observed for average throughput, about 12% NR BS throughput degradation is observed for cell edge throughput.QC(R4-2415306): T-put loss 48%, edge T-put loss 78%OPPO (R4-2415596): 0 SINR degradationvivo (R4-2415764): 22% throughput loss for average throughput, 39.4% throughput loss for cell edgeEricsson (R4-2415453): No significant impact on victim system | TBA |  |
| h | NR UL->device | CMCC (R4-2414996): SINR degradation is less than 1dB. Outage percentage consider SINR level with 10% BLER is 0% for both device 1 and 2aQC(R4-2415306): MarginalOPPO (R4-2415596): 0dB SINR degradation @5%, 0.03dB SINR degradation @ 50%vivo (R4-2415764): 0dB SINR degradation Ericsson (R4-2415453): No significant impact on victim system | SINR degradation is less than 1dB.TBD on the outage percentage. |  |
| **5-2** | **D2T2-A2-legacy UE indoor** | R2D: ULCW2D and D2R: UL | e | Device->NR UL | CMCC (R4-2414996): No throughput degradation for NR system for average throughput and cell edge throughputQC(R4-2415306): Marginalvivo (R4-2415764): impact is ignorableEricsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor | No NR UL throughput degradation for both average throughput and cell edge throughput is observed |  |
| f | NR UL->reader | CMCC (R4-2414996): when 10% indoor UE, SINR degradation is 20dB for cell edge and 4.8dB for average. Outage percentage consider SINR level with 10% BLER is 24% for device 1 and 22% for device 2aQC(R4-2415306): when 100% indoor UE, SINR degradation @5-ile is 13dB, @50-ile is 4.9 dB with 130dB CW cancellation capability.vivo (R4-2415764): SINR degradation is much higher than 1dB Ericsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor | SINR degradation is larger than 1dB.TBD on the SINR degradationTBD on the outage percentage |  |
| g | Reader->NR UL | CMCC (R4-2414996): when 10% indoor UE, about 6% throughput degradation is observed for average throughput, about 12% NR BS throughput degradation is observed for cell edge throughput.QC(R4-2415306): when 100% indoor UE, Mean T-put loss 65%, cell edge T-put is N/A due to outageOPPO (R4-2415596): 0.04dB SINR degradation @5%, 2.87 dB SINR degradation@50%vivo (R4-2415764): when 10% indoor UE, 13.7% throughput loss for average; when 100% indoor UE, 17.9% throughput loss for average.Ericsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor | NR UL throughput degradation for both average throughput and cell edge throughput is observed. *Note: TBD on the throughput degradation level* |  |
| h | NR UL->device | CMCC (R4-2414996): When 10% legacy NR UE indoor, SINR degradation is 3dB for cell edge and 5dB for average. Outage percentage consider SINR level with 10% BLER is 5% for device 1 and 0% for device 2aQC(R4-2415306): When 100% legacy NR UE indoor, 1.9dB for 5-ile SINR degradation, 2.8dB for 50-ile SINR degradationOPPO (R4-2415596): When 10% legacy NR UE indoor, 6.32dB SINR degradation @5%, 11.76dB SINR degradation @50%; when 100% legacy NR UE indoor, 16.41dB SINR degradation @5%, 25.14 dB SINR degradation @50%.vivo (R4-2415764): When 10% indoor UE, 4.68dB SINR degradation @ 5%, 5.74dB SINR degradation @ 50%; when 100% indoor UE, 14.55dB SINR degradation @5%, 18.38dB SINR degradation @ 50%Ericsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor | SINR degradation is larger than 1dB.TBD on the SINR degradationTBD on the outage percentage |  |
| **6-1(O)** | **D2T2-B-legacy UE only outdoor** | R2D: ULCW2D and D2R: DL | a | Device->NR DL | vivo (R4-2415764): No throughput lossEricsson (R4-2415453): No significant impact on victim system |  |  |
| b | NR DL->reader | vivo (R4-2415764): SINR degradation is less than 1dBEricsson (R4-2415453): Significant impact pending further understanding of LLS |  |  |
| g | Reader->NR UL | vivo (R4-2415764): 11% average throughput loss, 31.68% cell edge throughput lossEricsson (R4-2415453): No significant impact on victim system |  |  |
| h | NR UL->device | vivo (R4-2415764): No SINR degradationEricsson (R4-2415453): No significant impact on victim system |  |  |
| **6-2(O)** | **D2T2-B-legacy UE indoor** | R2D: ULCW2D and D2R: DL | a | Device->NR DL | vivo (R4-2415764): when 10% indoor UE, throughput loss is smaller than 5%. When 100% indoor UE, more than 10% throughput loss is observed.Ericsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor |  |  |
| b | NR DL->reader | vivo (R4-2415764): SINR degradation is less than 1dBEricsson (R4-2415453): Significant impact pending further understanding of LLS |  |  |
| g | Reader->NR UL | vivo (R4-2415764): 12.23% ~ 18.85% throughput loss.Ericsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor |  |  |
| h | NR UL->device | vivo (R4-2415764): when 10% indoor UE, 4.45dB SINR degradation @5%, 5.27dB SINR degradation @50%. When 100% indoor UE, 14.71dB SINR degradation @5%, 23.96dB SINR degradation @50%Ericsson (R4-2415453): No significant impact on victim system with 10% of the NR UE indoor |  |  |