3GPP TSG-RAN WG4 Meeting #116bis R4-25xxxxx

**Prague, Czech Republic, Oct. 13-17, 2025**

**Agenda item:** 6.11.1

**Source:** Qualcomm Incorporated

**Title:** AI/ML ad-hoc meeting minutes

**Document for:** Approval

# Introduction

The discussion on the AI/ML study is organized in thread [112]. The ad-hoc meeting will discuss some of the topics from the moderator summary in [1].

# Discussion

## Topic #1: CSI reporting requirement and testing framework for CSI prediction

## Topic #2: RRM core requirement and testing framework for beam management

### Sub-topic 2-1

*Measurement period for inference – case 2*

The requirements for case 2 are not yet finalized, there are still some FFS from the agreement in RAN4#116

**Issue 2-1: Measurement period for inference – case 2**

Proposals

* + Option 1: T=1
  + Option 2: T is fixed, different than 1 (2 or 4)?
  + Option 3: T is based on capability
  + Option 4: Others
* Recommended WF
  + Option 1

Proponents of Option 3 should explain why T depends on implementation and what is the system benefit to have different T for different UEs and longer measurement(observation) period

Discussion:

Vivo: we should follow the RAN1 design, we should have more samples than just 1

QC: RAN1 had this discussion in the last meeting. Minimum number of samples. We should simply replace T with K which was defined by RAN1, can have different values

Nokia: T is only mulipying M or M\*N\*P

Moderator: should be M\*N\*P

E///: we should have T=4, shouldn’t rely on RAN1

Apple: we understand RAN1 agreement, does this apply for every inference report? If it’s a periodic resource, what would the UE do.

Nokia: if K is a number of samples, and M is the number of samples, what is the difference?

ZTE: we should have M in [], it can be redundant. Both K and M are number of samples.

QC: this is confusing, M was 1 or 3 in legacy L1-RSRP measurements. We can keep [] for now and come back after RAN1 made final agreement.

Agreement:

Measurement period for inference – case 2

K(number of samples)\*[M]\*N\*P

K as defined by RAN1

### Sub-topic 2-2

*Reporting delay*

Some agreements on the reporting delay were reached in previous meetings, however , the entire timeline should be clarified so it can be included in the specifications. Some companies are proposing to include d’ and/or Z3’ in the requirements to align with RAN1. This reporting delay will be added to the measurement(observation) period.

**Issue 2-2: Reporting delay**

* Proposals
  + Option 1: introduce inference/reporting delay as Z3’+d’
  + Option 2: reference RAN1 specifications, in RAN4 specs mention that UE should report in the reporting occasion occurring after the specified delay
  + Option 3: no need for an explicit reporting delay, just define a measurement delay which includes the reporting delay
  + Option 4: others
* Recommended WF
  + To be discussed

Discussion:

Nokia: we should follow the legacy approach, Option 3

Apple: RAN1 has considered this delay with Z3’ and d’, this should be enough

QC: if we are just focusing on measurement duration, if we are focusing on reporting delay. Z3’ does not need to be considered. d’ should be there.

Nokia: should we have some number for d’ and test?

QC: d’ will not be negligible

Nokia: in legacy we only have a measurmenet requirement which also covers the reporting delay for periodic reporting. If d’ is negligible.

MTK: in legacy we have a reporting delay. We would still prefer to have a clear report delay

QC: in legacy this was defined as max of reporting periodicity and measurement periodicity, we can now simply add d’ to the measurement periodicity.

Nokia: we should wait for d’ definition

E///:if we add d’ in the RAN4 spec, this might be duplicating the inference delay

Apple: this would only be done for periodic reporting, not for aperiodic. Only for aperiodic we would reuse directly 214 spec

Agreement for reporting delay:

Reuse d’ as to be agreed by RAN1

d’ to be added to the measurement period to reflect the extra time needed by the UE to perform inference

Depending on the RAN1 specifications, d’ shall not be double counted in the overall delay for periodic, aperiodic or semi-persistent reporting

Final specifications to be agreed after RAN1 includes d’ in the specs

### Sub-topic 2-3

*Reporting delay requirements for monitoring*

Multiple companies proposed to introduce reporting delay requirements for RS-PAI

**Issue 2-3: Reporting delay requirements for monitoring**

* Proposals
  + Option 1: RAN4 to introduce reporting delay requirements for monitoring
    - Delay to be defined from when UE receives command/configuration to report until the report is sent
  + Option 2: Do not introduce delay requirements
  + Option 3: Others
* Recommended WF
  + Option 1

Further discussion on the exact definition of the delay is needed

Discussion:

MTK: we have concern to define requirements for this. It doesn’t seem possible to define the accuracy requirement. If this is only to check that the UE reports something we can discuss

Nokia: our understand is that this RS-PAI is reported in the CSI report. Since we have no delay for CSI reporting delay, we can probably just reuse the CSI timeline and we do not need any explicit RAN4 reporting delay requirement

Samsung: we agree with MTK and Nokia. We think it would be impossible to define an accuracy requirement. We do not need any delay requirement

QC: we agree with MTK an Samsung that we should not have any accuracy requirement. We cannot reuse the CSI timeline because of colisions of different resources.

Agreement:

Do not define any explicit requirements for reporting delay of RS-PAI performance monitoring metric.

### Sub-topic 2-4

*Draft CRs*

Two draft CRs with the agreements so far were submitted, these should be discussed. R4-2513413 and R4-2514311

**Issue 2-4: Draft CRs**

* Points for discussion on the draft CRs
  + TCI state switching delay
    - Modify the existing clause on known condition or introduce a new one for AI/ML based prediction
    - Adopt the change proposed in R4-2513413 (introduce T0) or modify the text as in R4-2514311
    - Other changes/suggestions
  + Performance monitoring for AI/ML operation
    - Introduce a new clause for general performance monitoring and subclauses for CSI and Beam prediction monitoring
    - Introduce separate clauses for CSI and beam prediction (not under a general clause for AI/ML monitoring)
    - Introduce subclause under clause 8 or only for measurement reporting delays under clause 9?
    - Others
  + Functionality activation delay
    - Is this clause needed or not?
    - Should it cover just beam management or also CSI
    - Other comments on title/text
  + L1-RSRP prediction report requirements
    - Should SSB also be covered or not?
    - Introduce a new clause for prediction(R4-2513413) or modify existing clause on L1-RSRP reporting (R4-2514311)
    - Separate into Measurement reporting requirements and L1-RSRP measurement and prediction requirements?
      * Further separate based on SSB and CSI-RS
    - Other comments on requirements structure, text, etc
  + Other high level issues for CRs
* Recommended WF
  + To be discussed

Discussion:

Requirements to be captured:

* + TCI state switching delay
  + L1-RSRP prediction report requirements
    - Cover both SSB and CSI-RS
  + Performance monitoring for AI/ML operation – TBD after discussion on CSI monitoring

Do not introduce any activation delay requirements

CR drafting:

Introduce a new suffix for beam prediction requirements – X (applicable for all new requirements related to beam prediction)

For TCI state switching, introduce a new clause 8.10.2X replicating the known TCI state condition clause for the beam prediction use case

For L1-RSRP, introduce requirements also for SSB to SSB prediction for ~~case 1 and~~ case 2, reuse the same requirements as CSI-RS as applicable (for example only periodic resources)

Introduce new clause on L1-RSRP measurements for prediction 9.5X, include SSB based prediction and CSI-RS based prediction as different subclauses

For performance requirements (including test cases), consider separately SSB to SSB, SSB to CSI-RS and CSI-RS to CSI-RS prediction cases, including downselecting to even a single case.

### Sub-topic 2-5

*Simulation results*

**Issue 2-5: Simulation results**

* Proposals
  + Option 1: Discuss the simulation results based on summary – to be prepared by vivo
    - Simulation results
    - Refinement of simulation assumptions (e.g. error modelling, etc)
* Recommended WF
  + To be discussed

Discussion:

### Sub-topic 2-6

*KPIs for prediction*

The latest agreement on the KPIs for prediction were reached in R4-2505105

**Issue 2-1: Metrics/KPIs for beam ID prediction**

**Agreement:**

* Metrics/KPIs for beam ID prediction, at least for the case if only beam ID is reported:

The successful rate for the correct prediction,

* + The correct prediction is considered as maximum ground-truth RSRP among top-K predicted beams larger than or equal to the ground-truth RSRP of the strongest genie-aided beam(s) – x dB,
  + FFS on top-N (N</=K) predicted beams have to be considered in the success rate evaluation
    - FFS on N values
  + FFS on x values

Note: if x=0 and N=1, it means Top-K/1 (%) : the percentage of "the Top-1 strongest beam is one of the Top-K predicted beams"

**Issue 2-2: Absolute RSRP accuracy**

Agreement:

* Absolute RSRP accuracy requirement applies to Top-1 of predicted beams at least
  + FFS whether to apply to other beams

No further progress has been made on this topic, the main points for debate were whether the requirements should apply for more beams, not just the top predicted and how to ensure the reliability of at least some of the predicted beams.

**Issue 2-6: KPIs for predictionTest system setup**

* Proposals
  + Option 1: verify half of predicted beam N=K/2+1
  + Option 2: do not further consider top N (N=1), only consider x based on simulations
  + Option 3: set x=[1]dB, K=2 or 3
  + Option 4: Using K = 4, N = 2 and 0=X<2 dB
  + Option 5: other combination/parameters to ensure that if multiple beams are predicted within a narrow range of absolute RSRP, they are all reliably predicted
    - If there is only a single beam much stronger than others, reliability of prediction of the other beams has no material impact
  + Option 6: others
* Recommended WF
  + To be discussed

Discussion:

### Sub-topic 2-7

*Performance requirements for monitoring*

Multiple companies proposed to introduce requirements for RS-PAI reporting.

**Issue 2-7: Test system setup**

* Proposals:
  + Option 1: introduce accuracy requirements for RS-PAI
  + Option 2: do not introduce requirements for RS-PAI
* Recommended WF
  + Option 1

Actual details on how to introduce the requirements and corresponding tests can be discussed in the next meeting

Discussion:

### Sub-topic 2-8

*Test system setup*

A baseline for the test system was agreed in the last meeting, this will have to be further refined

**Issue 2-8: Test system setup**

* Points for discussion
  + Option 1: support 4 active cross-pol probes in a single plane: 0, 30, 90, 150degrees
    - A screen shot of a cell phone

      Description automatically generated
  + Option 2: emulate UE movement through UE rotation
  + Option 3: emulate UE movement through changes in power/Tx probe
  + Option 4: number of beams which can be emulated, is it possible to emulate 32 beams?
  + Option 5: A single-AoA “wireless-cable” setup driven by a fading/channel emulator to generate rich CDL channel conditions and spatially consistent mobility
* Recommended WF
  + To be discussed

Discussion:

### Sub-topic 2-9

*Test system channel model*

In the previous meeting it was agreed that a CDL-based channel model will be taken as starting point.Based on the agreements for the baseline test setup in the previous meeting, it should be further discussed which channels can be emulated with the baseline test setup and how to simplify the channel models.

**Issue 2-9: Simplified Channel models**

* Proposals
  + Option 1: RAN4 to continue evaluation of simplified channel models as proposed in R4-2514248 (R&S – 6 clusters, etc
  + Option 2: other channel simplification methods:
    - Revmoe the weak clusters that would not influence the UE beam management
    - Merge the clusters that have the same/similer AoAs
    - Reduce values of per-cluster parameters such as CASD, CASA, CZSD, CZSA
  + Option 3: It is not recommended to reduce the number of clusters in the UMi CDL-C model directly for simplification. There is a high risk of significantly altering the channel properties, potentially shifting the UMi characteristics to those of UMa or to an undefined channel property.
    - So, we can keep all the clusters of the CDL model, and use the following procedure that does not impact the fundamental channel characteristics:
      1. First, a spatial filter (38.901 Clause 7.7.4 & R4-) should be applied to the CDL-C model.
      2. Next, clusters with insufficient power can be ignored.
      3. Only the remaining clusters need to be represented in the chamber using probes.
  + Option 4: others
* Recommended WF
  + To be discussed

It should also be further discuss how to continue the study/evaluation with a simplified channel, how to incorporate this in the simulation and how to check the performance impact.

Discussion:

## Topic #3: RRM core requirement and testing framework for Positioning accuracy enhancement

### Sub-topic 3-1

*CR for Requirements for case 1*

In the previous meeting it was agreed to introduce reporting delay for case 1 based on the legacy requirement. The actual CR should be discussed and agreed.

**Issue 3-1: Requirements for case 1**

Proposals

* + Option 1: Endorse CR for case 1 in R4-2514353 (Nokia)
  + Option 2: others
* Recommended WF
  + Option 1

Please provide any comments on the draft CR

Discussion:

QC: general approach is fine, however, we haven’t agreed some of the parameters yet like number of samples or beam sweeping factors. We also had some questions on the delay uncertainty, where is this coming from.

Nokia: we didn’t explicitly mention everything, we took the structure of the legacy spec. we are willing to work to make any changes

E///: it’s not easy to understand some of those details. It is possible to have simultaneous measurements, we should look at all those. It should be clarified that the location request should be for case 1.

Vivo: requirements are not clear, this should be verifiable by a test. For example, there is no definition of the inference time. We should also clarify other parameters.

Nokia: inference delay is hard to define.

QC: we can provide a value on inference time for the next meeting, other companies can do the same. We propose to use the measurement time from Rel-17.

E///: we can agree the parameters, then it should be easy to come up with the final CR in the next meeting.

QC: we need Rx TEG to increase the robustness, better estimate can be obtained.

E///: Rx TEG is not considered for case 1. For legacy, the number was clear but this is not the case for case 1

Vivo: can we reuse the legacy requirements for RSTD as delay?

QC: we take the legacy RSTD requirements and plug into this delay, we can also do all the cases, with and w/o gap

E///: we should clarify that measurements in connected are only within the gap. This would be the simplest requirement

Agreement:

To be clarified in the requirements:

* Request location information message should refer to “case 1” positiniong
* Reuse the legacy RSTD measurement delay for all the cases (with gap, w/o gap, PRS aggregation)
* Beam sweeping factor for FR2 including sweeping reduction factor
  + Take the legacy values
* Rx TEG: check on signaling, take the legacy(used in RSTD measurements) approach if it is signaled
* Cover all RRC states

CR structure:

* Introduce new clause for AI/ML based positioning case 1
* Reference existing requirements wherever they are reused to avoid duplicating the same requirement

Introduce requirements for each RRC state in the corresponding clauses:

Draft for RRC idle: Nokia

Draft for RRC connected: E///

Draft for RRC inactive: Nokia

### Sub-topic 3-2

*CR for case 3a/3b*

A draft CR was already technically endorsed in the last meeting. A formal CR could agreed in this meeting for case 3a/3b.

**Issue 3-2: CR for case 3a/3b**

Proposals

* + Option 1: merge Clauses 13.3 13.6 from R4-2513670 (CMCC) into R4-2514119 (Ericsson) and endorse final CR
  + Option 2: Others
* Recommended WF
  + Option 1

Discussion:

CMCC: we are fine to merge

E///: the changes for Rx-Tx part are fine. For the RSRP and RSRPP are not in the RAN3 spec, these are not needed. RSRP/RSRPB is not supported as output of the AI/ML model so they are not reported

CMCC: we will further check

Agreement:

Clause 13.2(Rx-Tx reporting) from R4-2513670 (CMCC) to be merged into R4-2514119 (Ericsson).

CMCC to further check until end of this meeting on other clauses

E/// to provide final CR in RAN4#117

### Sub-topic 3-3

*Testing for case 1*

**Issue 3-3: Testing for case 1**

* Proposals
  + Option 1: Introduce 2 tests, one for FR1 and one for FR2
    - Tests to be based on the legacy tests as proposed in R4-2514118
  + Option 2: Do not define any tests
  + Option 3: others
* Recommended WF
  + To be discussed

Discussion:

Nokia: we don’t have any accuracy requirements, what are we testing?

E///: this would only be a delay test

CMCC: we also support Option 1

E///: we should do tests only in RRC connected, single CC

Vivo: this is more of a functionality test. We should only do a test with RSTD and do only 1 test, for example without gaps. Shorter testing time would be preferred

CMCC: we define requirements for all states, why only do a test in connected?

E/// it’s just our proposal

QC: using just connected is easier from a test procedure point of view. We will reuse the final requirements including the inference delay to be agreed, correct?

E///: yes

Agreement:

Introduce “case 1” tests only for reporting delay, one for FR1 and one for FR2

* Only connected mode
* Only reporting delay to be tested
* Only for the case with gaps

### Sub-topic 3-4

*Combinations of positioning features or positioning and other features*

In R4-2514117 it is proposed to introduce requirements for combinations of other features and positioning case 1 or for capabilities introduced for other feature which could have impact on positioning.

**Issue 3-4: Combinations of features and positioning case 1**

* Proposals
  + Option 1: Introduce multiple requirements for combinations of features and positioning case 1, such examples are
    - UE configured to perform positioning measurements for case-1 and “legacy” PRS based measurements
    - Requirements for the cases in which the UE supports reduce number of samples
    - Requirements for UEs supporting reduced rx beam sweeping factor
    - Impact of the number of Rx TEGs on the measurement period requirement
  + Option 2: Do not introduced requirements for such combinations, this will become untractable as there can be too many combinations of features
    - Only keep the baseline requirements
  + Option 3: others
* Recommended WF
  + Option 2

Discussion:

## Topic #4: General

### Sub-topic 4-1

*UE features*

In previous meetings it was agreed to introduce the UE features below.

**Issue 4-1: UE Features**

Proposals

* + Option 1: Confirm UE feature as in the table below

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Features** | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Need for the gNB to know if the feature is supported** | **Applicable to the capability signalling exchange between UEs (V2X WI only)”.** | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | **Need of FDD/TDD differentiation** | **Need of FR1/FR2 differentiation** | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | **Note** | **Mandatory/Optional** |
| 59. NR\_AIML\_air | [59-1-x] | UE-side beam prediction for BM Case1 | [Knows RX beam of predicted TX beam in setA in BM-case 1 if the predicted Tx beam is not QCL Type-D to a known TX beam] | **Pre-requisitng FG: 58-1-2 (RAN1 feature for BM-case-1)** | yes | N/A | [In BM-case 1, network needs to transmit additional samples of reference signal corresponding to the predicted TX beam of setA so that UE can sweep its RX beams during TCI state switch process when the RS resource for predicted Tx beam is the RS in target TCI state or QCLed to target TCI state.] | [Per Band] | [TDD] | [FR2-1 only] | N/A |  | [Optional with capability signaling] |
|  | [59-1-y] | UE-side beam prediction for BM Case2 | [Knows RX beam of predicted TX beam in setA in BM-case-2 if the predicted Tx beam is not QCL Type-D to a known TX beam] | **Pre-requisitng FG: 58-1-4 (RAN1 feature for BM-case-2)** | yes | N/A | [In BM-case 2, network needs to transmit additional samples of reference signal corresponding to the predicted TX beam of setA so that UE can sweep its RX beams during TCI state switch process when the RS resource for predicted Tx beam is the RS in target TCI state or QCLed to target TCI state.] | [Per Band] | [TDD] | [FR2-1 only] | N/A |  | [Optional with capability signaling] |

* + Option 2: other features are needed
* Recommended WF
  + Option 1

# References

[1] R4-2514519, “Topic summary for [116bis][112] R19 AI for air interface”, Moderator(Qualcomm Incorporated), RAN4#116bis