3GPP TSG-RAN WG4 Meeting #116 R4-250xxxx

**Bengaluru, India, 25th – 29th August, 2025**

**Agenda item:** 7.17.1

**Source:** Qualcomm Incorporated

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

**Document for:** Approval

# Introduction

The discussion on the AI/ML study is organized in two threads [126] and [127] in RAN4#114-bis. 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

### Sub-topic 1-1

*Performance monitoring*

Several companies proposed to introduce Type 3 performance with SGCS reporting

**Issue 1-1: Performance monitoring**

* Proposals
  + Option 1: Introduce requirements for Type 3 performance monitoring
  + Option 2: other performance monitoring framework/requirement
  + Option 3: do not introduce any monitoring requirements
* Recommended WF

Option 1

Discussion:

Apple: this is just high level about some requirements

Moderator: yes

Agreement:

RAN4 will introduce requirements for Type 3 performance monitoring for CSI prediction

FSS which requirements are to be introduced.

### Sub-topic 1-2

*Requirements for monitoring*

A framework for the monitoring requirements should be discussed and agreed

**Issue 1-2: Requirement baseline**

* Proposals
  + Option 1: Introduce reporting delay, accuracy and reporting mapping requirements
    - Reporting delay should follow the same framework as for beam management use case
      * Delay to be defined as the period from the time when UE sends RRCReconfigurationComplete message in response to the configuration of monitoring RS resources via RRCReconfiguration, to the time when UE reports the first performance monitoring metric.
  + Option 2: Others
* Recommended WF
  + Option 1, discuss if the proposed delay definition can be agreed

Discussion:

Qualcomm: RAN1 already agreed the report mapping. It is already agreed how SGCS is mapped to bits. The proposals on the delay is focused on periodic, we should discuss these details later.

Apple: we should still have the mapping in 38.133 in section 10. Even if RAN1 agreed, we still have something in RAN4 specs. For the accuracy we are not sure.

E///: regarding the mapping table, RAN1 already have a mapping table in 211. Regarding accuracy, I don’t know whether to put the accuracy in 133 or 101-4. This would be a performance discussion

Samsung: RAN1 design has 4 bits for SGCS. We should define the mapping between those bits and what value is meant by each value.

Oppo: for the accuracy, it is not clear how to test. We need to specify some requirements.

Qualcomm: for the accuracy, the only way to have a requirement is to check that the report exceeds a threshold. This is only way to pass the test.

Ericsson: from a network point of view, we are always worried about the accuracy reporting.

Apple: we might be able to test indirectly.

Agreement:

Introduce the following requirements for CSI performance monitoring:

* Reporting delay
  + FFS how the delay is defined
* Reporting accuracy
  + FFS on whether accuracy requirement can be defined/checked
* Mapping table – To be checked whether RAN1 captures or RAN4
* If it is not feasible to define reporting accuracy requirement or test it, RAN4 will send an LS to RAN1 to inform RAN1 about this

### Sub-topic 1-3

*CSI Prediction activation delay*

**Issue 1-3: Activation delay for CSI Prediction**

|  |
| --- |
| **Agreement from General Aspect (BM use case) RAN4#115:**  **Activation delay:**   * **For semi-persistent CSI reporting** * **Activation delay starts at the reception of the MAC-CE/DCI** * **For aperiodic CSI reporting** * **Activation delay starts at the reception of the DCI** |

* Proposals
  + Option 1: Introduce activation delay for CSI prediction for both periodic and aperiodic (or semi-persistent) reporting

Activation delay starting time

* + For period CSI reporting, activation delay starts when UE sends RRCReconfigurationComplete message containing applicable functionality report.
  + For aperiodic CSI reporting, activation delay starts at the reception of the DCI.
  + For semi-persistent CSI reporting, activation delay starts at the reception of the MAC-CE/DCI.

Activation delay ending time

* + RAN4 to consider first inference report as the end point to define activation delay requirements for periodic/aperiodic/semi-persistent CSI reporting for CSI prediction use cases.
  + Delay value TBD, to be discussed/agreed in next meeting
  + Option 2: No need for any explicit activation delay, can be handled as any other RRC reconfiguration
  + Option 3: others
* Recommended WF
  + To be discussed

Discussion:

CMCC: we support to define activation delay, for prediction only semi-persistent or aperiodic is supported so no need to consider periodic

Apple: in our understand it would need a requirement if it is something extra compared ot the usual RRC configuration. What is the difference between this and reporting of other measurements or CSI currently?

Qualcomm: agree with CMCC, not needed for periodic. For semi-persistent and aperiodic, proposals is that it starts from the command to report until it is sent. How is this different from regular prediction. It would be implicitly tested during the test for inference.

CMCC: we think this case is similar is same as for BM prediction, we agreed that we will define activation delay and starting point

Xiaomi: for CSI reporting we just have the normal timeline. We do not have any dedicated requirement for such reporting timelines

Oppo: we need to think about this, compared to the legacy solution there could be extra delays on this.

Nokia: we agree with CMCC and oppo about LCM, we think that activation is a more important aspect. First report could be a special report

MTK: first report could be different than the subsequent ones. For the 1st one, the UE needs to decode the MAC-CE. UE might need several observations to get the prediction. UE might have to wait for the observation window. Whether the model is active/loaded will depend on implementation.

### Sub-topic 1-4

*Reporting delay requirement*

The delay between the CSI-RS and UCI containing the report with the predicted PMI should be agreed

**Issue 1-4: Reporting delay requirement**

* Proposals
  + Option 1: Use 4ms separation between CSI-RS and predicted PMI report
  + Option 2: Use 4+Xms separation between CSI-RS and predicted PMI report
    - X to be defined by RAN1
  + Option 3: wait for RAN1 decision
  + Option 4: other
* Recommended WF
  + Option 3

Discussion:

Qualcomm: RAN1 has started discussing this, we should for RAN1 discussion

Apple: this should not be from periodic. This should come from RAN1, nothing RAN4 needs to do.

Agreement:

Option 3

### Sub-topic 1-5

*Scheduling delay*

The delay from when the UE prediction is send until the time the TE applies should be discussed and agreed

**Issue 1-5: Scheduling delay**

* Proposals
  + Option 1: n+4
  + Option 2: n+3
  + Option 3: n+2
  + Option 4: others
* Recommended WF
  + Option 1

Discussion:

### Sub-topic 1-6

*Generalization*

Several companies proposed to further study generalization issues and how to ensure that the UE performance does not degrade under different conditions.

**Issue 1-6: Generalization**

* Proposals
  + Option 1: Introduce tests with different MCSs
    - MCS 13
    - MCS4
    - MCS19
    - MCS20
    - >MCS20
  + Option 2: Introduce tests for different throughput metrics:
    - 90%
    - 70%
    - 30%
  + Option 3: different SNR points
  + Option 4: Combinations of the above
  + Option 5: further discuss after more evaluation through simulation
* Recommended WF
  + To be discussed

Discussion:

### Sub-topic 1-7

*Doppler values*

There are proposals to further limit the Doppler values being consider

**Issue 1-7: Doppler values**

* Proposals
  + Option 1: keep 20Hz and 50Hz
  + Option 2: keep only 20Hz
  + Option 3: others
* Recommended WF
  + Option 1

Discussion:

### Sub-topic 1-8

*Simulation results and next steps*

Several companies provided simulation results based on the agreed assumptions. The results and next steps in the simulation evaluation campaign should be discussed

**Issue 1-8: Simulation results**

* Proposals
  + Discuss the simulation results and next steps
    - Simulation results
    - Refinement of parameters:
      * Introduce realistic channel estimation
      * Further discuss CSI-RS configuration, codebook configuration, Dopller, SNR, etc
* Recommended WF
  + To be discussed

Discussion on refinement of simulation parameters to be done mainly offline

Discussion:

Oppo: we have more simulation results, for step 2, there is good alignment among 3 companies. We would more input for step 3, so far no good alignemtn. We should further check the assumptions and more input is needed.

Oppo to lead the offline discussion on the next steps for the simulation campaign.

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

### Sub-topic 2-1

*Measurement period for inference*

Some agreements were made for case 1 but case 2 was still TBD. As this requirement will impact the core, it is important that progress is made

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

Proposals

* + Option 1: reuse existing measurement period (existing M, N, P) for both case 1 and case 2
    - Agree the baseline requirements, discuss if this should be combined with any other features in future meetings
  + Option 2: reusing existing measurement period (existing M,N,P) for case 1, introduce a scaling factor T to increase the delay for case 2
    - T defined as a capability or dependent on M, N, P
  + Option 3: other options
* Recommended WF
  + Option 1

From a network operation point of view, it seems best to have consistent delays irrespective of which case is used.

If option 2 is preferred, how to define the additional scaling factor should be further discussed

Moderator recommends we do not combine the BM prediction feature with any other feature because there would be no time to finalize the requirements and specification would become unnecessarily complex.

Discussion:

Vivo: we support option 1, for case 1 we should have 1 shot measurement. For case 2, not clear. For combination with other features, we should check.

Qualcomm: we support option 2, but for case 2 we should have multiple samples. We could have it a fixed value.

MKT: UE might have to do both legacy measurenets and AI based prediction. UE can follow what it can do in legacy. The legacy measurement should stay the same.

Vivo: T would depend on how accuracy we can be. Will we have different accuracy requirements for case 1 and case 2?

Nokia: observation period is not clearly defined now

Xiaomi: observation window is better than period

Vivo: will we do sims for case 2 ?

Samsung: we agree with the contents, T is part of core, how are we going to decide that in such short time

Agreement:

observation period for prediction: (observation period is the amount of time during which UE samples the reference signals to make 1 prediction report)

For case 1 reuse M,N,P from legacy measurement requirements

For case 2, use T\*M, N P (M,N,P same as legacy measurement requirement)

FFS on T value, T can also be 1. T can also be based on capability

This observation period is to be used for the prediction delay requirement

### Sub-topic 2-2

*Prediction report delay*

For the final requirement, a timeline between measurement and the final report should be established

**Issue 2-2: Prediction report delay**

* Proposals
  + Option 1: Overall timeline to be measurement delay + inference delay + report
  + Option 2: others
* Recommended WF
  + Option 1

Inference delay should be further discussed. For now can be introduced a parameter but some numbers will be needed to finalize the requirements

Discussion:

### Sub-topic 2-3

*TCI State Handling*

In the previous meeting several agreements were reached regarding the handling of TCI state switching relative to whether it is known/unknown and the UE Rx beam knowledge. The agreements are listed above.

**Issue 2-3: TCI State Handling**

* Proposals for known TCI state
  + Detectability and SNR conditions:
    - Option 1:
      * The UE has sent at least 1 L1-RSRP report for the target/predicted TCI state before the TCI state switch command
      * The TCI state remains detectable during the TCI state switching period
      * The SSB associated with the TCI state remain detectable during the TCI switching period
        + SNR of the TCI state ≥ -3 dB
      * For BM case-1 and case-2, when the target TCI state is predicted (in Set A) and is not QCL-D to any previously measured RS, there is no physical RS transmission for the target. Therefore, the conditions of "detectable RS" and "SNR ≥ -3dB" cannot be applied and should be exempted.​
    - Option 2: others
  + Time conditions:
    - Option 1: TCI state switch command is received within 1280 ms upon the last transmission of the RS resource for beam reporting or measurement
    - Option 2: TCI state switch command is received within X\*1280 ms upon the last transmission of the RS resources for beam reporting or measurement
      * X can depend on case 1/2 and can be 1
    - Option 3:
      * For BM case 1, TCI state switch command is received within T\_prediction\_valid upon the last transmission of the RS resources for reporting. T\_prediction\_valid is a prediction-validity time related to channel coherence; FFS value/range.
      * For BM case 2, TCI state switch command is received within Tprediction\_time\_period + Tprediction\_valid upon the last transmission of the RS resources for beam reporting .
    - Option 4:
      * option 1 when target TCI state is based on RS from set A that is QCL type-D to a known measured TX beam.
      * Option 2 when target TCI state is based on RS from set A that is not QCL type-D to a known Tx beam and UE reports [TCI state known] capability.
    - Option 5: others
  + QCL relationship:
    - Option 1: Target TCI state is based on RS from set A beams with QCL relationship configured to a set B beam
    - Option 2: For BM case-1, if the predicted Tx beam in Set A is QCL Type-D to a known measured Tx beam, where TX beam can be both inside or outside set B, the corresponding Rx beam is known.
    - Option 3: If the predicted Tx beam in Set A is not QCL Type-D to a known Tx beam, known TCI state conditions shall be updated as
      * UE reports [TCI state known] in Capability X, and
    - Option 4:
      * For BM-Case 1, when the UE has the capability to know the corresponding Rx beam, RAN4 needs to further discuss:
        + If the UE supports this capability, for MAC-CE-based TCI state switch delay for known TCI state, whether the UE still needs to perform fine time tracking—i.e., whether TOk can be 0 and under what conditions.
      * For BM-Case 2, regarding the MAC-CE-based TCI state switch delay, when the UE has the capability to know the corresponding Rx beam, RAN4 needs to further discuss:
        + If the UE supports this capability, should the L1-RSRP measurement and fine time tracking delay always be defined according to the unknown TCI state case?
        + Potential side condition: The L1-RSRP measurement must wait until the corresponding TCI state takes effect before it can be performed (i.e., the L1-RSRP measurement cannot be executed earlier than the earliest predicted time instance of the target TCI state).
    - Option 5: Known if predicted beam is the RS in target TCI or QCL-ed to the target TCI state
    - Option 6: RS resource for of predicted-L1-RSRP measurement is the RS in target TCI state or QCLed to the target TCI state
* Recommended WF
  + Detectability and SNR conditions:
    - Option 1
  + Time conditions:
    - Option 1
  + QCL relationship:
    - To be discussed

Discussion:

### Sub-topic 2-4

*Activation delay*

Some companies are proposing to discuss/introduce an activation delay when the UE is configured to report predictions

**Issue 2-4: Activation delay**

* Proposals
  + Option 1: No need for any additional delay definition, delay of legacy procedures (RRC reconfiguration, etc) can be reused
  + Option 2: Introduce a separate delay from RRC reconfiguration until UE starts sending prediction reports
    - Requirement definition is FFS, should be agreed in the next meeting
  + Option 3: others
* Recommended WF
  + Option 1

If option 2 is to be agreed, concrete proposals on how to define the requirement and what should be studied/considered should be presented

Discussion:

### Sub-topic 2-5

*Simulation results*

**Issue 2-5: How to proceed with defining metrics based on Simulation results**

Discuss the following Options based on summary of simulation results–prepared by vivo

* Proposals
  + Option 1: Continue aligning on the following aspects
    - Prediction model
      * Companies clarify the model they used (or whether they applied the reference model provided in the simulation assumptions) when submitting results in the next meeting.
    - Dataset
      * Companies should perform simulations based on the reference dataset and submit results in the next meeting.
      * Alternatively, agree on dataset-related parameter settings (e.g., dataset size) in this meeting, and companies should submit results based on the aligned dataset parameters in the next meeting.
  + Option 2: In the next meeting, decide the value of metric based on the simulation results submitted by companies.
    - The source for the metric value can be determined by directly taking the average of the results from companies and applying certain criteria to exclude results with excessively large deviations
  + Option 3: other parameters or assumptions to be clarified/modified
* Recommended WF
  + To be discussed

Discussion:

# References

[1] R4-2504684, “Topic summary for [114bis][126] NR\_AIML\_air\_part1”, Moderator(Qualcomm Incorporated), RAN4#114-bis