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:

### 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:

### 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:

### 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:

### 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:

## 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:

### 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