**3GPP TSG-RAN WG4 #** **116-bis R4-2514588**

**Prague, Czech Republic, 13th October 2025 – 17th October 2025**

**Agenda item:** 8.1

**Source:** Feature lead (MediaTek inc.)

**Title:** WF on [116bis][106] 6G Demod

**Document for:** Approval

# Introduction

This document captures agreements and open issues for FS\_6G\_Radio under AI 8.8 corresponding to RAN4 driven non-AI demod topics at RAN4#116bis. All proposals have been saved for future inspiration.

# Topic #1: 6G demod

## Open issue and agreement summary

### Sub-topic: General aspects

**RAN4 demod study timeline**

* Proposals
  + Option 1: For RAN4 6G Demodulation, RAN4 establish a more realistic and structured timeline to ensure adequate depth in technical deliberation and a well-paced progression toward completion.
  + Option 2: RAN4 closely follow RAN1's discussion progress on other parameters related to 6G physical layer structure. Once relevant conclusions are available, RAN4 could consider adopting them for RAN4 6G Demodulation study.
  + Option 3: Postpone RAN4 discussion on demodulation requirements related to physical layer channel and procedure design until sufficient progress reached in RAN1 i.e., no early than Q2’26.
  + Option 4: 5GA Topics that were studied and proven useful should be introduced from day 1 in 6G, and RAN4 needs start discussions on corresponding test specifications to enable early adoption.

**Waveform and modulation study**

* Proposals
  + Option 1: RAN4 6G Demodulation could start with CP-OFDM and DFT-s-OFDM waveforms for 6G uplink demodulation study, and CP-OFDM waveform for 6G downlink demodulation study.
  + Option 2: RAN4 6G Demodulation study should cover following modulation schemes at least
    - For downlink, QPSK, 16QAM, 64QAM, 256QAM and 1024QAM
    - For uplink with CP-OFDM waveform, QPSK, 16QAM, 64QAM, 256QAM
    - For uplink with DFT-s-OFDM waveform, pi/2 BPSK, QPSK, 16QAM, 64QAM, 256QAM
  + Option 3: RAN4 needs to develop testable specifications for waveform, frame structure, channel coding, and modulation as defined by RAN1, ensuring that these can be practically implemented and validated in real products.

**SCS**

* Proposals
  + Option 1: RAN4 6G Demodulation study could start with following SCS options.
    - For sub 6GHz, 15kHz SCS for FDD, 30KHz SCS for TDD
    - For around 7GHz, 30kHz, 60kHz
    - For around 15GHz, 60kHz
    - For between 24.25GHz - 52.6GHz, 120kHz

**Demodulation specification principles**

* Proposals
  + Option 1: For 6G Demodulation specification structures, take TS38.101-4 as a starting point.
  + Option 2: For 6G Demodulation specification drafting principles, the descriptions of test parameters should be aligned with RAN1/RAN2 descriptions as much as possible, in order to avoid ambiguous understanding.
  + Option 3: For FRCs in 6G Demodulation specification, prefer to use a formula-based or pseudo-code-based definition for FRCs instead of table-based approach listing every parameter combination.
    - Option 3A: RAN4 needs to discuss how to specify FRC table in the specification for both BS and UE demodulation performance, considering the discussion in SI modernization of specification format and procedures for 6G.

**Broadcast and feedback-less channels/signals testing**

* Proposals
  + Option 1: RAN4 to assume broadcast and feedback-less channels/signals to be testable. RAN4 to recommend to RAN5 to define needed test solutions.

**ISAC study**

* Proposals
  + Option 1: RAN4 to study the demodulation for ISAC for 6G.

**Conducted and radiated testing**

* Proposals
  + Option 1: Conducted test method can be considered for FR1 frequency range, and OTA test method can be considered for FR2 frequency range for both UE and BS demodulation requirements.
  + Option 2: RAN4 must define test methodologies for FR3, including whether measurements are conducted or OTA.

### Sub-topic: Channel models

**Channel type**

* Proposals
  + Option 1: Clarify use of TDL and SCM models for 6G
    - Option 1A: Use rCDL baseline for MIMO.
    - Option 1B: Use CDL/rCDL as baseline for 6G.
    - Option 1C: Maintain TDL and CDL.
    - Option 1D: Continue TDL for simplicity.
    - Option 1E: Include xTDL.
    - Option 1F: Define default CDL propagation models.
    - Option 1G: Adoption of SCM should be justified for each test purpose.
    - Option 1H: Study practical MIMO correlation matrices for TDL.
    - Option 1I: Use rCDL baseline for MIMO and a limited number of TDL requirements for MIMO features with single layer transmission.
    - Option 1J: select one channel model (either TDL or CDL) for one specific feature.
      * Option 1Ja: The criteria of selection should be clarified and applied for all features.

**Specialized propagation channels**

* Proposals
  + Option 1: RAN4 evaluate candidate channel model for DL and UL considering new use cases including AI, ISAC, NTN, HST.
  + Option 2: We propose initiating a similar study for NTN scenarios, focusing on the CDL-D variant to reflect the LOS-dominant nature of NTN links and enable more accurate performance evaluations for NTN systems under practical deployment scenarios.

**Frequency related aspects of channel model**

* Proposals
  + Option 1: Study new frequency range.
    - Option1A: Study new frequency ranges of 6G
      * Derive CDL for 7-15 GHz.
    - Option1B: Study FR2.
    - Option 1C: Evaluate necessity and study spatial channel model for other frequency ranges in 6GR.
  + Option 2: Study if channel model is agnostic to different carrier frequencies or separate models are needed.
  + Option 3: The key issue to be discussed for the 6GR study is the number of antennas required for different frequency ranges.

**Uplink aspects of channel model**

* Proposals
  + Option 1: Study UL CDL for BS variants.
    - Option 1a: Study UL CDL for BS variants if key issues in DL CDL study are settled.

**AI/ML aspects of channel model**

* Proposals
  + Option 1: AIML extensions to the SCM framework shall be studied by the AIML 6GR study, if needed.
  + Option 2: Study and develop channel modelling methodologies for requirements targeting AI/ML use cases.
  + Option 3: Consideration of CDL modeling in 6GR for AI/ML receiver evaluations should follow the identification of robust countermeasures to prevent overfitting to deterministic channel behavior.

**Channel model alignment**

* Proposals
  + Option 1: To ensure the alignment of CDL implementation, channel properties such as PSD, time correlation coefficient and frequency correlation coefficient should be aligned apart from SNR points alignment.

**PMI bias**

* Proposals
  + Option 1: Consideration of CDL modeling in 6GR for PMI report evaluation should follow the identification of robust countermeasures to prevent overfitting to deterministic channel behavior.

**Other issues of channel model**

* Proposals
  + Option 1: If any important issues are not treated in 5G-A stage, capture in 6G study.

### Sub-topic: Receiver assumptions

**Receiver assumption for UE**

* Proposals
  + Option 1: MMSE-IRC as a baseline receiver.
  + Option 2: MMSE-IRC and R-ML as baseline receivers.
    - CMCC: with the prerequisite that the receiver is transparent to the network and does not require any PHY layer modification and additional assistance information.
  + Option 3: Cover advanced receivers (R-ML, soft-IC)
    - CT: Study the required information for advanced Rec for MU-MIMO.
  + Option 4: Study baseline and simplified structures.
  + Option 5: Study widely linear MMSE-IRC.

**Receiver assumption for BS**

* Proposals
  + Option 1: MMSE-IRC as a baseline receiver.
  + Option 2: Study feasibility of considering higher than 8Rx scenarios.

### Sub-topic: TxEVM and SNR

**TxEVM aspects**

* Feature Lead notes
  + TxEVM related discussion has been captured in Ad-hoc minutes.
* Proposals
  + Option 1: Study what EVM simulations assumptions should be used in demodulation and CSI requirements.
    - Option 1A: Study impact of TX EVM for higher modulation order/ MIMO layers on Demodulation requirements.
    - Option 1B: RAN4 shall abandon the SNR operating point limitations via fixed 20dB rule, or fixed TE TxEVM assumptions, and adopt a SNR limitation derivation based on actual TDRA/FDRA configuration.
    - Option 1C: RAN4 should study whether the TxEVM requirements for the base station, at least in the simulations for deriving the demodulation requirements, could be tightened.

**SNR aspects**

* Feature Lead notes
  + SNR related discussion has been captured in Ad-hoc minutes.
* Proposals
  + Option 1: To ensure good field coverage, the SNR values in the demodulation requirements should follow the SSB SNR values that can be measured in existing 5G NR scenarios and those SSB SNR values that can be expected in upcoming 6G deployments.
  + Option 2: RAN4 should study whether the coverage range for relevant field scenarios can be extended by defining demodulation requirements for larger SNR values as currently being used in 5G NR.
  + Option 3: RAN4 should study whether the coverage range for relevant field scenarios can be extended for carrier aggregation. It should also be studied whether the SNR requirement should be dependent on the number of component carriers.
  + Option 4: RAN4 shall abandon the SNR operating point limitations via fixed 20dB rule, or fixed TE TxEVM assumptions, and adopt a SNR limitation derivation based on actual TDRA/FDRA configuration.

### Sub-topic: Interference modelling aspects

**Interference profile**

* Proposals
  + Option 1: Study the interference profile for 6G DL/UL intra-cell and inter-cell interference scenarios.
    - Option 1A: RAN4 further evaluate interference profiles for intra-cell/interference cell scenarios: gNB and UE configuration e.g., power class, antenna configuration Homogenous and heterogenous scenarios Asynchronization TDD or dynamic TDD scenario Semi-static/Dynamic SBFD operation in gNB.
    - Option 1B: For 6G Demodulation with interference modelling, further discussion, and analysis on the modelling of directions, INRs, modulation orders of interference(s), number of layers from interference(s) are needed.
  + Option 2: RAN4 should also be prepared to deal with the possible interference caused by MRSS, by interference cancellation or mitigation.

### Sub-topic: Performance testing and requirement

**General performance requirement aspects**

* Agreement
  + In 6G SI, RAN4 will study how to strive to develop a demod/test performance requirement framework for the minimum performance to better reflect real field conditions than 5G, if necessary, by taking into consideration of the requirement/test coverage/alignmentablity and the test feasibility, complexity and cost/resources.

**Demodulation testing**

* Proposals
  + Option 1: For 6G demodulation study, use FRC style, MCS value, fixed rank, fixed channel bandwidth, fixed subframe configuration as a starting point.
  + Option 2: Study extending scope of demodulation tests with link adaptation.
  + Option 3: RAN4 needs to discuss the additional margins and measurements uncertainty for requirements definition of 6GR.
  + Option 4: RAN4 needs to discuss the SNR derivation procedure for 6GR, the span of ideal results span is <= [X] dB.

**CSI reporting test methodologies**

* Proposals
  + Option 1: We propose streamlining CQI reporting testing into 1-step approach and setting requirements in terms of throughput/SNR and BLER limits.
  + Option 2: We propose to study the necessity of CQI reporting requirements in addition to combined demodulation and link adaptation testing.
  + Option 3: We propose simplifying the PMI reporting testing process and setting requirements directly in terms of throughput/SNR instead of measuring γ.
  + Option 4: We propose to study the necessity of PMI reporting requirements in addition to combined demodulation and link adaptation testing.
  + Option 5: Study RI reporting requirements test metrics and test methodologies.
    - Option 5A: RAN4 to investigate alternative metric that measures consistency and accuracy of Rank Indicator (RI).

### Sub-topic: New TE functionalities

**OLLA with link adaptation**

* Feature Lead notes
  + Option 1 discussion has been captured in Chairman and Ad-hoc minutes. Feature lead’s suggestion based on discussion is that companies can be encouraged to consider technical solutions on OLLA in the next meeting as several companies see value to study OLLA as part of 6G demod SI.
* Proposals
  + Option 1: Study to include OLLA in ATP requirements.
    - Option 1A: Use proposed OLLA model from R4-2300703 as a starting point.
    - Option 1B: Study the feasibility to include OLLA in ATP requirements.

**SRS based precoding**

* Feature Lead notes
  + Option 1 discussion has been captured in Ad-hoc minutes. Feature lead’s suggestion based on discussion is that companies can be encouraged to consider technical solutions on SRS based precoding in the next meeting as several companies see value to study SRS based precoding as part of 6G demod SI.
* Proposals
  + Option 1: Define baseline SRS based precoding procedure in TE to enable aligned simulation assumptions.

**Time/frequency/phase offset precompensation**

* Feature Lead notes
  + Discussion of Option 1 has been captured in Ad-hoc minutes. Feature lead’s suggestion based on discussion is that companies can be encouraged to consider technical solutions on time/frequency/phase offset precompensation in the next meeting as several companies see value to study time/frequency/phase offset precompensation as part of 6G demod SI.
* Proposals
  + Option 1: RAN4 to study inclusion of higher layer aspects in demodulation requirements via dynamic TE decisions using known algorithms, e.g., applying timing offset reports (CJT).

**Other new TE functionalities**

* Feature Lead notes
  + Discussion of following options has been captured in Ad-hoc minutes.
* Proposals
  + Option 1: RAN4 to study inclusion of higher layer aspects in demodulation requirements via increased and dynamic application of DUT feedback in the TE.
  + Option 2: RAN4 to study inclusion of higher layer aspects in demodulation requirements via dynamic TE decisions using known algorithms, e.g., SU/MU scheduling, dynamic resource allocation/slots.
  + Option 3:RAN4 should explore utilizing test equipment algorithms to evaluate features that rely on network-side processing, enabling realistic UE performance assessment without limiting network implementation flexibility.
  + Option 4:RAN4 should identify features dependent on network-side processing and aim to define corresponding performance requirements, where feasible, using test equipment-based evaluation methods.

### Sub-topic: UE classification and applicability

**UE classification**

* Proposals
  + Option 1: RAN4 to study demod requirement handling for UE classifications and agree on questions such as a baseline set of requirements for all devices vs. individual requirements for each UE classification.

**Applicability rules**

* Proposals
  + Option 1: RAN4 should discuss improving Demodulation spec in 6GR by replacing broad applicability statements with clear, centralized mappings of test coverage. This would enhance consistency and reduce ambiguity across device types and configurations.
  + Option 2: RAN4 should implement a capability-aware test applicability framework that considers device functionality. For devices lacking legacy TN support, test applicability should be designed to avoid dependency on TN-related procedures and corresponding test cases.

**Device types**

* Proposals
  + Option 1: RAN4 should wait for further clarification in RAN and RAN1 what device types may get defined. Afterwards RAN4 should discuss how device types can be covered in the test framework of RAN4.

### Sub-topic: Uplink demod

**Digital Pre-Distortion and Post-Distortion Techniques**

* Proposals
  + Option 1: RAN4 to clarify the extent to which 6G UEs may support digital pre-distortion.
  + Option 2: DPoD at the BS receiver offers solution to compensate UE RF non-linearity to reduce UEs MPR for higher order and thus improve UL high data rate availability.
  + Option 3: RAN4 should study UL post-distortion techniques that jointly compensate for multiple non-linear components in the UE RF chain to improve uplink performance and efficiency.
  + Option 4: RAN4 to evaluate the potential MPR reduction enabled by DPoD and its impact on UL coverage and UE transmit energy efficiency.
  + Option 5: RAN4 to evaluate the extent to which UE EVM requirements can be adjusted when DPoD compensates for PA and other RF components non-linearity at the base station.
  + Option 6: RAN4 to study inclusion of oscillator phase noise and IQ imbalance in UL post-distortion schemes, evaluating feasibility and performance gains for high-order modulations and higher-frequency operation.
  + Option 7: RAN4 to evaluate DPoD performance with higher modulation orders focusing on high-SNR conditions.

**UE RF Impairment Modelling and Compensation**

* Proposals
  + Option 1: Beyond just the PA model, the entire UE RF front-end needs to be studied by RAN4, with particular attention to the potential variation in impairments across different UEs.
  + Option 2: RAN4 to study feasibility of UE non-linearity estimation methods with reference signals or actual data and assess their suitability for supporting post-distortion and compensation techniques.
  + Option 3: RAN4 to evaluate RF front-end variation from multiple UEs in the market into account and define suitable baseline/reference models for UL post-distortion studies.
  + Option 4: RAN4 to evaluate UE PA non-linearity and related impairments across both FR1 and FR2 for UL-Post distortion compensation at BS receiver. Further, this would impact both BS and UE model.

**EVM Requirements and Network Control**

* Proposals
  + Option 1: RAN4 could consider adjusting the UE EVM requirements but also evaluate any additional constraints or dependencies affecting this limit.
  + Option 2: UE may adjust EVM and reduce MPR only under explicit network control; otherwise, existing RF requirements apply.

**Evaluation Methods and Simulation Models**

* Proposals
  + Option 1: RAN4 to study CP-OFDM and DFT-s-OFDM for UL evaluation of this feature.
  + Option 2: RAN4 to evaluate channel models for link-level simulation with DPoD feature, considering their impact on test metrics under higher UE transmit power.

# References

[1] R4-2514513, Topic Summary for [116bis][106] 6G Demod, MediaTek inc.

[2] R4-2514589, Ad-hoc meeting minutes on 6G demod, MediaTek inc.