**3GPP TSG-RAN WG4 Meeting # 112 R4-2412832**

**Maastricht, 19 – 23 August, 2024**

**Agenda item:** 8.18.4

**Source:** Moderator (Samsung)

**Title:** Topic summary for [112][130] NR\_MIMO\_Ph5\_UE

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion (e.g. list of treated agenda items) and provide some guidelines for email discussion if necessary.*

The latest WID on Rel-19 NR MIMO Phase 5 includes following objectives in the WID [1]. RAN4 is mentioned to specify necessary core requirements for the enhancements.

|  |
| --- |
| 1. Specify enhancement to facilitate UE-initiated/event-driven beam management for reducing overhead and/or latency, assuming the unified TCI while leveraging (as much as possible) legacy CSI measurement and reporting configuration frameworks, targeting FR2 and sTRP with intra- and inter-cell beam management
	1. UL signaling content(s) (and procedure(s) as required) for UE-initiated/event-driven beam reporting facilitating fast beam switching
	2. UL signaling medium/container considering the UE-initiated/event-driven nature of the UL transmission, designed primarily for the purpose of beam reporting
2. Specify CSI support for up to 128 CSI-RS ports, targeting FR1
	1. Type-I codebook refinement supporting up to a total of 128 CSI-RS ports across all resources, assuming legacy CSI-RS resources (with up to 32 CSI-RS ports per resource), based on extension of legacy codebooks
	2. Type-II codebook refinement supporting up to a total of 128 CSI-RS ports across all resources, assuming legacy CSI-RS resources (with up to 32 CSI-RS ports per resource), based on extension of legacy codebooks, without modifying any codebook parameter other than introducing additional values for the number of ports codebook parameter(s)
	3. Extension of CRI(s)-based CSI reporting (CQI/PMI/RI calculated per CRI for ≥1 CRIs) for hybrid beamforming supporting up to a total of 128 CSI-RS ports across all resources, with up to 32 CSI-RS ports per resource, without new codebook design
3. Specify UE reporting enhancement for CJT deployments under non-ideal synchronization and backhaul, targeting FR1, both FDD and TDD
4. Inter-TRP time misalignment and frequency/phase offset measurement and reporting, assuming legacy CSI-RS design, with stand-alone aperiodic reporting on PUSCH

 1. Specify non-coherent UL codebook to facilitate 3-antenna-port codebook-based transmissions, without enhancement on UL full power transmission and without enhancement on SRS resource

Note: UL full power transmission mode 1 and 2 are not supported.1. Specify enhancement for asymmetric DL sTRP/UL mTRP deployment scenarios, assuming intra-band intra-DU non-co-located mTRP scenarios, without changing existing cell definition or defining a new cell (e.g. UL-only cell), assuming the Rel-17/18 unified TCI framework and fully reusing the legacy QCL/UL spatial relation rules, targeting FR1 and FR2
	1. Two closed-loop PC adjustment states for SRS, both separate from PUSCH; and pathloss offset configurations for pathloss calculation to UL TRP(s), when the pathloss RS is from DL sTRP.
 |

This document is to discuss UE RF requirement aspects of Rel-19 NR MIMO objectives based on contributions.

# Topic #1: General

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2412134**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412134.zip) | Samsung | Proposal: It is proposed for RAN4 to approve the UE RF part of RAN4 MIMO work plan in Table 2. |
| [**R4-2413224**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413224.zip) | Qualcomm Incorporated | Proposal 1: RAN4 to adopt scenario 2 above as the basis for an FR2 UE RF requirement for the Rel-19 asymmetric connection objective. |

## Open issues summary

*Before Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1: Overall work plan

*Sub-topic description:*

*Open issues and candidate options before meeting:*

**Issue 1-1: UE RF work plan approval**

* Proposals

|  |  |
| --- | --- |
| **Meeting** | **Target Plan** |
| **RAN4#112 (Aug, ’24)** | * Agree overall work plan for core and performance part
* Discuss and identify potential impact on UE RF requirements
* Discuss and identify potential impact on RRM core requirements
 |
| **RAN4#112-bis (Oct, ’24)** | UE RF | * Initiate discussion on UE RF requirements of identified impact
* Continue to check other impact on UE RF requirement
 |
| RRM Core | * Discuss and identify which RRM requirements need to be developed to support MIMO Phase 5
 |
| **RAN4#113 (Nov, ’24)** | UE RF | * Continue to discuss UE RF requirements of identified impact
 |
| RRM Core | * Further discussions on UE RRM requirements impact for MIMO evolution features
* Discuss the possible signalling impact (e.g. UE capabilities, network flag)
 |
| **RAN4#114 (Feb, ’25)** | UE RF | * Continue to discuss and define UE RF requirements of identified impact
 |
| RRM Core | * Continue to discuss and define RRM requirements of identified impacts
 |
| **RAN4#114-bis (Apr, ’25)** | UE RF | * Continue to discuss and define UE RF requirements of identified impact
* Review draft CRs for endorsement if any
 |
| RRM Core | * Continue to discuss and define RRM requirements of identified impacts
 |
| **RAN4#115 (May, ’25)** | UE RF | * Try to agree RAN4 CR to finalize the RF core requirements
 |
| RRM Core | * Continue to discuss and decide the solution for the RRM requirements
* Review draft CRs for endorsement if any
 |
| RRM perf | * Initial discussion on RRM performance part for MIMO evolution
 |
| Demod | * Initial discussion on demod/CSI requirements, discuss and identify which demod/CSI requirements need to be extended
 |
| **RAN4#116 (Aug, ’25)** | UE RF | * Agree RAN4 CR to finalize the RF core requirements
 |
| RRM Core | * Agree RAN4 CR to finalize the RRM core requirements
 |
| RRM perf  | * Further discussion on RRM performance part for MIMO Phase 5
 |
| Demod | * Further discussion on demod/CSI requirements, define scenario parameters in order to align simulation cases
 |
| **Core part completion** |
| **RAN4#116-bis (Oct, ’25)** | RRM perf | * Further discussion on RRM performance part for MIMO Phase 5,
 |
| Demod | * Further discussion on demod/CSI requirements, provide initial simulation results to align results from companies, CR split
 |
| **RAN4#117 (Nov, ’25)** | RRM perf | * Provide draft CR on TS38.133 for RRM performance part, endorsed if possible.
 |
| Demod | * Provide simulation results and continue to discuss demod/CSI requirements, provide draft CR, endorsed if possible.
 |
| **RAN4#118 (Feb, ’26)** | RRM perf  | * Further work on the draft CRs and Agree RAN4 CR to finalize the RRM performance part
 |
| Demod | * Further work on the draft CRs and Agree RAN4 CR to finalize the demod/CSI part
 |
| **Performance part completion** |

* + Option 1: Agreeable
	+ Option 2: After revision
* Recommended WF
	+ Agree on UE RF part pending further decision in RRM session

### Sub-topic 1-2: UE RF impact

*Sub-topic description:*

*Open issues and candidate options before meeting:*

**Issue 1-2: UE RF impact of 3Tx**

* Proposals
	+ Option 1: Identified. Start with 3Tx
	+ Option 2: Not yet. Wait for further progress in RAN1
* Recommended WF
	+ Option 1

Agreement: RAN4 will analyse the impact of 3Tx on UE RF requirements.

**Issue 1-3: UE RF impact of asymmetric DL sTRP/UL mTRP**

* Proposals
	+ Option 1: Identified (e.g., spherical coverage with a different TCI state for UL compared to DL)
	+ Option 2: Not yet. Wait for further progress in RAN1
* Recommended WF
	+ Option 1

Huawei: I wonder if the comments are on the same page. The target scenario is not aligned with RAN1.

Vivo: This scenario does exist. It is not scenario introduced from Rel-19. I wonder if we can discuss this from Rel-19. M-TRP scenario was not considered before.

Nokia: We think the main impact is on the RRM and demodulation to deploy the mTRP. For UE RF, we can use the current specification.

Samsung: we do not consider the scenario that uplink TRP can transmit any reference signal. It is not time to discuss this type of scenario.

Qualcomm: The scenario come up with is based on the objective of the WID. There is no limitation that the uplink only TRP cannot supply downlink. We try to come up with UE to help FR2 uplink coverage.

# Topic #2: 3-antenna-port transmissions (3Tx)

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2411634**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411634.zip) | Qualcomm Technologies Int | Proposal 1: Update table 6.2.D.1-3 with the 3Tx mode-full power TPMIs as given below once TPMIs numbers are allocated to themProposal 2: Allow 3Tx feature to support PC3 and PC2.Proposal 3: Create MPR tables for 3Tx for both UE handheld and CPE/FWA devices. Use 10 dB antenna-antenna isolation for UE handhelds and 20 dB antenna-antenna isolation for CPE/FWA devices. |
| [**R4-2412095**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412095.zip) | vivo | Observation 1: Among the objectives within the WID, only 3Tx Codebook Transmission has clear RAN4 UE RF impact.Proposal 1: Defining requirements for 3Tx Codebook Transmission.Observation 2: RAN1 agreements related to RAN4 RF are codebook definition, power splitting behavior, full power mode and DCI indication. Others such as SRS resource configurations, PTRS related and M-TRP related do not have direct impact.Proposal 2: RAN4 impact for 3Tx are mainly for MOP for UL-MIMO.Proposal 3: Introduce MOP requirements based on following configuration:Non-full power mode: 3 Layers, TPMI 0, $\frac{1}{\sqrt{3}}\left[\begin{matrix}1&0&0\\0&1&0\\0&0&1\end{matrix}\right]$Full power mode 0: 1 layer, TPMI 0,1,2, $\frac{1}{\sqrt{3}}\left[\begin{array}{c}1\\0\\0\end{array}\right],\frac{1}{\sqrt{3}}\left[\begin{array}{c}0\\1\\0\end{array}\right],\frac{1}{\sqrt{3}}\left[\begin{array}{c}0\\0\\1\end{array}\right]$Proposal 4: Wait for further clarification by RAN1 on how to differentiate 3Tx and 4Tx in MOP configuration since legacy method of using “*nrofSRS-Ports*” cannot be used anymore.Proposal 5: Discuss if some UE type restriction should be made on the UE type for 3Tx, especially for the case of full power mode 0.Proposal 6: Do not consider RAN4 impact of 3T6R in MIMO Phase 5 WI since it already covered by another RAN4 WI.Proposal 7: Keep track on possible up scoping of WI in RAN. |
| [**R4-2412135**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412135.zip) | Samsung | Observation 1: 3Tx discussion is on the fair way toward the current goal in the WID in RAN1.Proposal 1: RAN4 should first initiate the discussion with the 3Tx UE RF requirementsObservation 2: RAN4 had a WI on 3Tx for NR inter-band UL Carrier Aggregation (CA) and EN-DC.Observation 3: RAN4 discussed requirements to enable 4Tx on a single carrier for CPE/FWA/vehicle/industrial devices.Proposal 2: RAN4 should take the results of previous 3Tx (two bands) and 4Tx (CPE/FWA/vehicle/industrial devices) studies for Rel-19 3Tx (single band) discussions as much as possible.Observation 4: RAN4 can first draw some basic assumptions from the justification part of the WID.Proposal 3: Target devices of the WI are not only FWA (larger form factor) devices, but also handheld (small form factor) devices.Proposal 4: RAN4 can concentrate on FR1 requirements based on our initial discussion on STxMP in Rel-18 and market demands.Observation 5: WI considers non coherent UL codebook only (1-port/layer up to 3 layers).Observation 6: There is no enhancement on NCB PUSCH with 3TxObservation 7: There is no enhancement on SRS resourceObservation 8: UL full power transmission mode 0 (full power mode) is considered onlyObservation 9: RAN4 first needs discussions for the baseline assumptions such as the relationship between PA configurations and applicable power classes, and the maximum power class/level.Proposal 5: It is proposed to consider a single PA configuration for each power class to specify the UE RF requirements of 3Tx as an initial stage.Observation 10: Existing MPR gap between 2 Tx and 4Tx for PC1.5 is up to 1.5 dB gap for FWA devices.Proposal 6: It is proposed to reuse existing MPR tables for dual Tx (handheld UE) as much as possible given our previous experience and efficient discussion in Rel-19. |
| [**R4-2412348**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412348.zip) | OPPO | Observation 1: The functionality of 3port codebook-based UL MIMO and 3T6R SRS antenna switching will be specified in RAN1.Observation 2: 3T6R SRS antenna switching has been covered in UE RF enhancement and this WI can focus on specifying 3Layer UL MIMO related requirements.Proposal 1: Specify 3Layer UL MIMO related requirements in this WI, leave SRS antenna switching requirements to UE RF enhancement WI, and not specifying 3Tx based ULFPTx requirements.Observation 3: During Rel-18 inter-band 3Tx, PC1.5 is the most interested power class, then PC2, and PC3 is keep jut to make the spec looks complete.Proposal 2: Specify 3Layer UL MIMO with PC1.5 as high priority in this WI, and check the interests for other power classes like PC2 and PC3. |
| [**R4-2412575**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412575.zip) | Huawei, HiSilicon | Proposal 1: For frequency range, suggest to clarify the RAN4 3Tx discussion scope under Rel-19 NR\_MIMO\_Ph5 WI as FR1 only. Proposal 2: For UE form factor, suggest to clarify the RAN4 3Tx discussion scope under Rel-19 NR\_MIMO\_Ph5 WI as non-handheld UE only. Proposal 3: For the power class targeting 3Tx UE, suggest to clarify the RAN4 3Tx discussion scope under Rel-19 NR\_MIMO\_Ph5 WI as PC1.5 only.Proposal 4: Reuse 4Tx PC1.5 MPR for 3Tx PC1.5 MPR requirement. FFS whether the one defined in TS 38.101-1 Table 6.2D.2-4 or Table 6.2D.2-5 can be selected. |
| [**R4-2413199**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413199.zip) | Nokia | Observation 1: The 3Tx case can be considered as a special case of 4Tx with one Tx muted based on the current standard Observation 2: The 3Tx antenna switch time should be between 2T4R and 2T8R which are supported for 2Tx UE in the current specification.Proposal 1: There is no impact for RAN4 UE RF specification to support 3Tx at the moment. Wait for RAN1 to further develop 3Tx specifications.Observation 3: The current discussion for such scenario is mainly related to UE capability and scheduling for UL transmissions toward more than one TRP. There is no RF impact foresee. Proposal 2: There seems no UE RF impact for asymmetric DL sTRP/UL mTRP deployment scenarios, wait for RAN1 to further develop it. |
| [**R4-2413367**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413367.zip) | Ericsson India Private Limited | Observation 1: In current specifications TS38.101-1, 2-antenna-port and 4-antenna-port transmissions are specified in clause “6.2D.1 UE maximum output power for UL MIMO”.Proposal 1: The requirements for 3-antenna-port codebook-based transmissions could be specified in clause “6.2D.1 UE maximum output power for UL MIMO” of TS38.101-1.Proposal 2: For 3-layer case, the maximum output power requirements shall be met with the UL MIMO configurations of using 3-layer UL MIMO codebook-based transmission with precoding matrix of $W=\frac{1}{\sqrt{3}}\left[\begin{matrix}1&0&0\\0&1&0\\0&0&1\end{matrix}\right]$.Proposal 3: Regarding the UL MIMO configuration in closed-loop spatial multiplexing scheme for which the maximum output power requirements shall be met, a row can be added to Table 6.2D.1-2 in TS38.101-1 for 3 layers and TPMI index [0] (to be further confirmed). Proposal 4: For the UE supporting full-power Mode 0 for UL MIMO, a PUSCH configuration for 3 Tx ports and 1 layer could be added to “Mode-full power” row of Table 6.2D.1-3 in TS38.101-1, with TPMI index [0,1,2] (to be further confirmed). |

## Open issues summary

*Before Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 2-1: General assumptions

*Sub-topic description:*

*Open issues and candidate options before meeting:*

**Issue 2-1: Applicable UE types**

* Proposals
	+ Option 1: Handheld UE included
	+ Option 2: Non-handheld UE only
	+ Option 3: Depend on condition (e.g., ULFPTx)
* Recommended WF
	+ Collect companies’ view

Ericsson: we should separate the discussion of 3Tx and mTRP part. Handheld UE is mentioned for 3Tx.

Qualcomm: We need include FWA and handheld. Both should be included.

Apple: We see the main feasibility for FWA. Handheld UE is challenging. We may consider two sets of requirements. Two sets of MPR due to different form factor.

Huawei: We share the similar view as Apple. Our understanding is that current spec, 4Tx is applied to non-handheld UE. Maybe Option 2 is better way to go.

OPPO: When the WID is drafted in RAN, there is no limitation of device type. The limitation to handheld is not agreed.

Vivo: My understanding is that currently RAN does not provide the clear guidance. Similar to Huawei view, maybe we can think that if some requirements are impacted and we can consider the different requirements.

Agreement:

* Both handheld and non-handheld UEs will be considered for UE RF requirements
	+ FFS on whether a single set or two sets of UE RF requirements, e.g., MPR, will be specified.

**Issue 2-2: Applicable Frequency Ranges**

* Proposals
	+ Option 1: FR1 only
	+ Option 2: Others
* Recommended WF
	+ Option 1

Ericsson: According to WID, both FR1 and FR2 are included for mTRP. For 3Tx, it should be FR1.

Agreement:

* Both FR1 and FR2 will be considered for potential UL mTRP requiremetns
* Only FR1 is considered for 3Tx objective

### Sub-topic 2-2: Power class

*Sub-topic description*

*Open issues and candidate options before meeting:*

**Issue 2-3: Power classes for 3Tx UL MIMO**

* Proposals
	+ Option 1: PC3 and PC2
	+ Option 2: PC1.5 only
	+ Option 3: Others
* Recommended WF
	+ Collect companies’ view

Qualcomm: We would like to suggest option 1. Mode 0 operation is expected, which is up to 4Tx. We do not see how we can include PC1.5.

Ericsson: We share the similar view as Qualcomm. What is the motivation to achieve PC3?

OPPO: we want to consider PC1.5.

ZTE: we share the similar view as OPPO.

Vivo: do we only consider TDD mode? No FDD? If we consider FDD, PC1.5 is problematic. Mode 0 cannot be implemented if we consider PC1.5.

Apple: We think PC1.5 is not valid target. We are more prefer to PC3 and PC2.

OPPO: Mode 0 is the enhanced feature. Any power class can be supported.

Huawei: Agree with OPPO comment. Even with assumption 3PA, it is difficult situation for FDD band.

Qualcomm: Mode 0 and release-15 UE behavior are available. Does 1-layer, 2-layer and 3-layer support release-15?

Chair: the 3Tx based TxD is precluded from the WID objectives.

**Issue 2-4: PA configurations**

* Proposals
	+ Option 1: Consider single PA configuration per power class
	+ Option 2: Others
* Recommended WF
	+ Collect companies’ view

### Sub-topic 2-3: MIMO configurations

*Sub-topic description*

*Open issues and candidate options before meeting:*

**Issue 2-5: Non ULFPTx mode**

* Proposals
	+ Option 1: 3-layer with precoding matrix of $W=\frac{1}{\sqrt{3}}\left[\begin{matrix}1&0&0\\0&1&0\\0&0&1\end{matrix}\right]$.
	+ Option 2: Others
* Recommended WF
	+ Option 1

Agreement:

* 3-layer with precoding matrix of $W=\frac{1}{\sqrt{3}}\left[\begin{matrix}1&0&0\\0&1&0\\0&0&1\end{matrix}\right]$

**Issue 2-6: ULFPTx mode 0**

* Proposals
	+ Option 1: Add both 1-layer and 2-layer for 3Tx with



* + Option 2: Add 1-layer for 3Tx with $W=\frac{1}{\sqrt{3}}\left[\begin{array}{c}1\\0\\0\end{array}\right],\frac{1}{\sqrt{3}}\left[\begin{array}{c}0\\1\\0\end{array}\right],\frac{1}{\sqrt{3}}\left[\begin{array}{c}0\\0\\1\end{array}\right]$
* Recommended WF
	+ Collect companies’ view

Qualcomm: We would like to support option 1. 1-layer and 2-layer are supported in RAN1.

Vivo: Option 2 is provided by us. The most configuration is 1-layer. For two-layer, although it is defined, it would be not necessary to define that.

Huawei: Agree with vivo founding.

Ericsson: How to define mode 0 for 2-layer? Mode 0 is only for 1-layer.

Nokia: We focus on 1-layer as baseline.

Vivo: RAN1 made sufficient agreements. We just need to discuss how to verify.

Tentative agreement:

* For the 3Tx UE RF requirements with ULFPTx mode 0
	+ Take 1-layer as baseline
	+ Further discuss whether 2-layer is needed

### Sub-topic 2-4: MPR

*Sub-topic description*

*Open issues and candidate options before meeting:*

**Issue 2-7: MPR for 3Tx**

* Proposals
	+ Option 1: Reuse existing MPR tables without simulation work
	+ Option 2: Others
* Recommended WF
	+ Option 1

OPPO: next meeting we can discuss it further. We need consider simulation.

Apple: It might depend on uplink transmission whether to use the existing MPR or not.

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