**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

**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

# 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

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

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

### 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

**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

**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

### 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

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