**3GPP TSG-RAN WG4 Meeting # 102-bis-e R4-220xxxx**

**Electronic Meeting, 21th Feb– 3th March, 2022**

**Agenda item:** 10.19.4

**Source:** Samsung

**Title:** WF on CSI requirement for Rel-17 FeMIMO

**Document for:** Approval

# Background

* R4-2203090, “WF on general and CSI requirement for Rel-17 FeMIMO”, Samsung. RAN4#101-bis-e meeting
* R4-2203091, “WF on demodulation requirement for Enhancement on HST-SFN deployment”, Samsung, RAN4#101-bis-e meeting
* R4-2203092, “WF on demodulation requirement for Enhancement on Multi-TRP”, Huawei, HiSilicon, RAN4#101-bis-e meeting

# CSI reporting requirement for multi-TRP

**Issue 3-1-1: Test cases for CSI reporting enhancement for m-TRP transmission**

Tentative agreements:

* Define PMI reporting requirement for single-DCI based Multi-TRP scheme with full overlapped resource allocation (SDM) only in FR1

Candidate Options

* FFS on additional CSI reporting requirement for single/multi-DCI based Multi-TRP scheme
	+ Option 1
		- Option 1a(Samsung, Nokia): Define new CSI reporting requirement for CQI reporting for Multi-DCI based Multi TRP scheme
		- Option 1b (Nokia, Intel): Define RI, CQI reporting requirement for single-DCI based Multi-TRP, and define CQI reporting requirement for multi-DCI
	+ Option 2(Apple, Huawei, Qualcomm, Ericsson, MTK): Not define RI, CQI reporting requirement for single-DCI, Not define CQI reporting requirement for multi-DCI

Recommended WF

* Comments encourage if any

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| **Company** | **Comments** |
| Apple | We support the tentative agreement and Option 2 for additional CSI reporting requirements.  |
| Qualcomm | We support the tentative agreement and Option 2 for the CSI reporting requirement. |
| Ericsson  | We don’t support introducing additional CSI reporting requirement for single/multi-DCI based Multi-TRP scheme. Only define PMI reporting requirement for single-DCI based transmission and no CSI requirement for multi-DCI based transmission.   |
| Mediatek | We still support Option 2. |
| Huawei | We prefer Option 2. |
| Nokia | Single-DCI:Nokia would prefer CQI, RI and PMI, but can compromise on defining new CSI reporting requirement for PMI only for the single-DCI based Multi-TRP scheme.Multi-DCI:For multi-DCI cases with non-overlapping PDSCH resources, the PMI/RI calculations for each TRP are not different from legacy. CQI on the other hand is shared among TRPs, so the legacy algorithm does no longer apply. Therefore, Nokia still prefer CQI reporting if feasible from a work plan perspectiveTherefor we suggest:Option 3: Define PMI reporting requirements in case of Single-DCIIf time allows define CQI reporting requirements in case of multi-DCI |

**Issue 3-2-1: Common simulation assumption**

Tentative agreements:

* Channel and correlation models: TDLA30-10 with XP High with statistically independent for each TRP
* Pc setting: Same Pc ratios for each TRP in defining requirement
* SNR setting: The SNRs for TRP #1 and TRP #2 are assumed to be balanced with a scaling factor of 1/sqrt(2) for the transmitted signal from each TRP

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| **Company** | **Comments** |
| Apple | We support the tentative agreement |
| Qualcomm | Okay with the tentative agreement |
| Ericsson | Fine with the tentative agreement |
| Mediatek | We are fine with the tentative agreement. |
| Huawei | OK with the tentative agreement. |
| Nokia | We are fine with the tentative agreement |

**Issue 3-2-2: General test set-up for CSI reporting**

Tentative agreements:

* 2 TPs configured with fully overlapping resource allocation
* One CSI-RS resource with Ks = 2
	+ TP1 associated with NZP-CSI-RS resource 1
	+ TP2 associated with NZP CSI-RS resource 2
* CSI reporting: One CSI associated with multi-TRP measurement hypothesis and X=0 CSI associated with single-TRP measurement hypothesis (CSI reporting mode 1 with X=0)
	+ CMR group 1 {CMR a} corresponding to NZP CSI-RS resource 1, K1=1
	+ CMR group 2 {CMR b} corresponding to NZP CSI-RS resource 2, K2=1
	+ CMR pair (N=1) : CMR {a,b} for M-TRP measurement hypothesis
* No time/frequency offset between two TPs
* WB PMI reporting for mode 1 with X=0

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| **Company** | **Comments** |
| Apple | We support the tentative agreement |
| Qualcomm | Okay with the tentative agreement |
| Ericsson  | Ok to be the baseline.   |
| Mediatek | We are fine with the tentative agreement. |
| Huawei | OK with the tentative agreement. |
| Nokia | We are fine with the tentative agreement |

**Issue 3-2-3: CSI resource configuration**

Tentative agreements:

* Configure two resources in a resource pair in the same slot for CSI reporting requirements for mTRP.

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| **Company** | **Comments** |
| Apple | We support the tentative agreement |
| Qualcomm | Okay with the tentative agreement |
| Ericsson  | Fine with tentative agreement. Same assumption as fully overlapping resource.  |
| Mediatek | We are fine with the tentative agreement. |
| Huawei | OK with the tentative agreement. |
| Nokia | We are fine with the tentative agreement |

**Issue 3-2-4: Number of CSI-RS Ports**

Candidate options:

* Option 1 (Qualcomm):
	+ 8 for each TRP
* Option 2 (Samsung, Apple, Huawei):
	+ 4 for each TRP

Recommended WF

* Encourage companies to check whether option 2 is acceptable based on Majority view?

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| **Company** | **Comments** |
| Apple | Option 2 is acceptable.  |
| Qualcomm | We think it could be difficult to define requirement with 4-port CSI-RS since the precoding gain could be minimal. However, we are okay to compromise on this and support Option 2 as a starting point, but would like to keep it open pending simulation results. |
| Ericsson  | We support to decide it in the next meeting based on the simulation results, e.g. throughput ratio with a given SNR test point.   |
| Mediatek | We are fine with the Option 2. However, we are fine to postpone final decision until simulation results are available. |
| Huawei | We prefer Option 2. |
| Nokia | We support option 2 as a starting point. |

**Issue 3-2-5: Number of layers**

Tentative agreements:

* Number of layers: 2 (1MIMO layer per TRP)

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| **Company** | **Comments** |
| Apple | We support the tentative agreement |
| Qualcomm | Okay with the tentative agreement |
| Ericsson  | Support the tentative agreements.   |
| Mediatek | We are fine with the tentative agreement. |
| Huawei | OK with the tentative agreement. |
| Nokia | We are fine with the tentative agreement |

**Issue 3-2-6: Test metric for PMI reporting**

Tentative agreements:

* Apply test metric of TP ratio follow PMI and random PMI with m-TRP reporting. The layer for random PMI per TRP should be orthogonal

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| **Company** | **Comments** |
| Apple | We support the tentative agreement |
| Qualcomm | Okay with the tentative agreement |
| Ericsson  | Support the tentative agreements.   |
| Mediatek | We are fine with the tentative agreements. |
| Huawei | OK with the tentative agreement. |
| Nokia | We are fine with the tentative agreement |

**Issue 3-2-7: Performance evaluation**

Candidate options:

* Option 1 (Apple): Evaluate performance of PMI reporting with enhanced CSI reporting against single PMI reporting for multi-TRP transmission.
* Option 2 (Huawei, Samsung): there is no necessary to do evaluations to find the gain for the enhanced CSI reporting comparing to the single-TRP hypothesis for multi-TRP scenario.

Recommended WF

* Interested companies can provide the performance evaluation of PMI reporting with enhanced CSI reporting against single PMI reporting for multi-TRP transmission. No impact on the PMI reporting requirement definition for single-DCI based Multi-TRP.

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| **Company** | **Comments** |
| Apple | We support the recommended WF.  |
| Ericsson  | Support the recommended WF.   |
| Mediatek | We support the recommended WF. |
| Huawei | OK with the recommended WF. |

**Issue 3-2-8: Codebook Structure**

Candidate options:

* Option 1: Reusing the existing Rel-15 PMI requirement setup: i.e, type I single panel

Recommended WF

* Option 1

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| **Company** | **Comments** |
| Apple | Option 1. |
| Qualcomm | Okay with the recommended WF |
| Ericsson  | Support the recommended WF.   |
| Mediatek | We are fine with the recommended WF. |
| Huawei | OK with the recommended WF. |

# PMI reporting requirement for Rel-17 enhanced ype II PS codebook

**Issue 4-1-1: Whether to define PMI requirement for Rel-17 FeTye II PS codebook**

Candidate options:

* Option 1 (Samsung, Nokia, Huawei, Intel): Yes
	+ Option 1a(Huawei): Define PMI reporting requirement for Rel-17 FeTypeII port selection codebook based on evaluation on the performance gain over eTypeII codebook.
	+ Option 1b(Ericsson): Consider defining PMI requirement for Rel-17 eType II port selection only if RAN4 can reach an agreement on a simplified way of testing with SU-MIMO test set-up, otherwise not to define requirement**.**
* Option 2 (Apple, Qualcomm): No

Recommended WF

* Option 1?

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| **Company** | **Comments** |
| Apple | We still support option 2. Both gNB and UE requirements need to be verified for eType II port selection if requirements are introduced, not only UE but also gNB requirements should be introduced.  |
| Qualcomm | We are of the opinion that the requirement for FeTypeII PS CB should not be defined in Rel-17. The gNB BF implementation is not standardized for FeTypeII PS CB, for which UE performance cannot be guaranteed. Even with the example in relation to LTE Rel-13 FD MIMO that came up during the first round of discussion, any restriction on the gNB BF does not guarantee optimal performance for UE. Therefore, it becomes more to a functional test. Furthermore, absence of a baseline performance from earlier releases, we don’t support introducing requirement for FeTypeII PS CB. |
| Ericsson  | We suggest to keep it open. In our view, whether to have such requirement depends on the test setup discussion, especially for the gNB implementation model and test metric(how to compare the performance and how to observe the enhancement benefit). We prefer to discuss together with test setup and test metric.     |
| Huawei | Further evaluation is needed to decide whether to define requirements based on the performance gains. |
| Nokia | We prefer option 1b to have PMI as baseline pending acceptance from the Test Equipment vendors for test set-up. Compromise proposal: keep the options open until next meeting so proponents of option 1 can bring more details on how a gNB implementation independent test set-up can be achieved |

**Issue 4-2-1: General Test seup of PMI reporting requirement**

Candidate options:

* Option 1 (Nokia): Both SU-MIMO and MU-MIMO
* Option 2 (Samsung, Huawei, Ericsson): SU-MIMO

Recommended WF

* SU-MIMO

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| **Company** | **Comments** |
| XXX |  |
| Ericsson  | SU-MIMO if the requirement is introduced.  |
| Huawei | OK with the recommended WF. |
| Nokia | The Rel-16 Port Selection codebook was mainly intended for MU-MIMO. The Rel-17 Port Selection codebook was intended for both SU-MIMO and MU-MIMO. Therefore, it is unfortunate if we cannot agree on testing both if the PMI requirement for Rel-17 Enhanced Type II Port Selection codebook is introduced |

**Issue 4-2-2: Modelling BF CSI-RS Port**

Candidate options:

* Option 1 (Samsung)
	+ Option 1a: MIMO fading channel as Rel-13 LTE Class B K=1 PMI test cases
	+ Option 1b: Power scaling method similar as Rel-13 LTE Class B K>1 CRI test case
* Option 2(Huawei)
	+ Further discuss the modeling method if PMI reporting requirement for FeTypeII port selection is introduced.
* Option 3(Nokia)
	+ Include feType II PS performance requirements utilizing CSI-RS transmission with a predetermined beam selection used in the transmission

Recommended WF

* Apply option 1 as starting point for initial evaluation

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| **Company** | **Comments** |
| XXX |  |
| Huawei | Further discussion is needed until next meeting. |
| Nokia | We suggest to leave the starting point for the initial evaluation open to not limit the directions for potential solutions |

# Other

**Issue 5-1-1: whether to define PMI reporting requirement for inter-cell interference scenario in Rel-17 FeMIMO**

Candidate Options

* Option 1(Huawei, Samsung, Qualcomm ): No
	+ Option 1a (Huawei): Firstly focus on the RAN1 feature for FeMIMO demodulation requirements definition considering the limitation TU for RAN4 FeMIMO performance part.
	+ Option 1b (Samsung): NO discussion/handling of the topic for PMI reporting under inter-cell interference in Rel-17 FeMIMO WI
		- This issue can be handled under either TEI-17 or Rel-18 specific WI pending on the consensus in RAN4
* Option 2(Ericsson, Verizon, AT&T): RAN4 to first evaluate the impact brought by false PMI reporting solution, then discuss a proper model to reveal this issue, and consider introducing the corresponding PMI reporting requirement to resolve this issue
* Option 3 (MTK, Ericsson, Verizon, AT&T ): RAN4 defines PMI reporting requirement for inter-cell interference scenario
* Option 4(Apple):
	+ RAN4 further evaluates PMI reporting in ICI before deciding to introduce requirements.
	+ The scope of PMI reporting in ICI is approved in FeMIMO WID or part TEI-17 for further discussion in RAN4.

Recommended WF

* Based on WID of Rel-17 FeMIMO WI, PMI reporting with inter-cell interference is out of FeMIMO WI scope. Following WID, moderator suggest to not define PMI reporting requirement with inter-cell interference in Rel-17 FeMIMO WI. Encourage companies to check whether it is acceptable?
* FFS on where to handle the PMI reporting requirement with inter-cell interference
	+ Option 1 (Apple, Samsung, MTK, Ericsson): Rel-17 TEI
	+ Option 2 (Qualcomm, Huawei, Samsung): Rel-18 timeframe
	+ Option 3 (Ericsson): Rel-17 FeMIMO

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| **Company** | **Comments** |
| Apple | We proposed that - o The scope of PMI reporting in ICI is approved in FeMIMO WID or part TEI-17 for further discussion in RAN4.Support option 1 from Moderator’s options. |
| Qualcomm | We support Option 2. Since it requires further evaluation, Rel-17 TEI may not be feasible. |
| Ericsson | We are also fine with option 1 if it is feasible.But we are afraid that introducing PMI reporting requirement with ICI is too big to be considered in the TEI, since it requires several meetings to discuss, evaluate and define corresponding requirements. In this case, we also propose to add the PMI reporting with ICI into the WID of Rel-17 FeMIMO WI to handle the discussion of defining requirement.  |
| AT&T | We are also OK with option 1 if the level of effort can be managed. We would be concerned if the Rel-17 TEI effort turned out to be similar to the TXD situation. We would also support option 3 as described by Ericsson. |
| Mediatek | We support Option 1. We are also fine with Option 3. |
| Intel | We support Option 1 and 3.  |
| Huawei | We prefer Option 2. |

**Issue 5-1-2: PMI reporting with inter-cell interference evaluation assumption**

Candidate Options

* Option 1(Apple, Ericsson, Verizon, AT&T): For further evaluation of PMI reporting in ICI use the following simulation assumptions:
	+ Antenna config: 8x2 XP High
	+ Prop. Channel model: TDLA30-5; ensure that channel from target and interference cell are statistically independent and have different beam direction (to ensure PMI are different)
	+ NZP CSI-RS for interference:
		- Overlapping with serving cell
		- Non-overlapping with serving cell
	+ CSI-IM for interference: non overlapping with CSI-IM for serving cell
	+ Loading for interference cell: PDSCH transmission is enabled in all slots for interference cell
	+ Evaluate performance based on TP ratio with and with ICI for (1) overlapping NZP CSI-RS (2) non-overlapping NZP CSI-RS

Recommended WF

* Pending on issue 5-1-1

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| **Company** | **Comments** |
| Apple | Option 1 if agreed to be further evaluated. |
| AT&T | Option 1 should be used as the baseline for further evaluation. |
| Mediatek | We are OK with Option 1. |

**Issue 5-1-3: Test metric of PMI reporting with inter-cell interference**

Candidate options:

* Option 1(MTK, Ericsson, Verizon, AT&T)
	+ TP ratio with following PMI with inter-cell interference and follow PMI without interference

Recommended WF

* Pending on issue 5-1-1

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| **Company** | **Comments** |
| Apple | Pending further evaluation and on whether new requirements are introduced |
| AT&T | Option 1 should be used as the baseline for the new test metric. |
| Mediatek | We support Option 1 and do not preclude other test metrics which can be used to verify the correct behavior of UE. |

# Reference

* R4-2207160, Email discussion summary fo [102-e][320] NR\_HST\_FR2\_Demod, Samsung, RAN4#102-e meeting