**3GPP TSG RAN #104**

**Shanghai, China, June 17th – 20th, 2024**

**Title: Moderator Summary for Rel-19 MIMO Issues**

**Source: RAN1 Chair (Samsung)**

# Introduction

This document covers RAN#104 discussions on the following contributions related to NR MIMO Phase 5.

* RP-241194 Views on the scope of Rel-19 MIMO WI Qualcomm Incorporated
* RP-241207 Views on scope of Rel-19 NR MIMO Phase 5 CMCC
* RP-241358 Rel-19 MIMO Scope MediaTek Inc.

Specifically, the following issues are discussed.

* Support of two TAs as part of enhancement for asymmetric DL sTRP/UL mTRP deployment scenarios
* SRS port grouping as part of CSI enhancement
* Partial-coherent UL codebook for 3Tx multi-panel
* Open loop based UL precoder cycling

# Two TAs

Two TAs was introduced into RAN1 as part of Rel-18 MIMO. In Rel-18, this feature is supported by means of indicating two TAs using separate DCIs for each TA value. In Rel-19, RAN1 discussed the support of this feature as part of enhancement for asymmetric DL sTRP/UL mTRP deployment scenarios. Unlike the Rel-18 scenario where each TRP can indicate its TA value using separate DCIs, in the asymmetric DL sTRP/UL mTRP scenario, one of the TRPs cannot transmit on the downlink. Therefore, two TAs would need to be supported using a single DCI if this feature is supported in Rel-19.

The companies involved in the RAN1#117 discussion had strong positive views on the support of two TAs in Rel-19. Some companies voiced that this feature would be critical in making asymmetric DL sTRP/UL mTRP deployment scenario practically useful. Note however that there was at least one company who did not agree that two TAs is within scope of Rel-19.

The moderator requests interested companies to provide their views on the support of two TAs as part of Rel-19 MIMO.

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| **Company** | **Comments** |
| Samsung | The support for 2TA for asymmetric DL/UL is essential to ensure that the technology is applicable not only when a UE is right at the middle of two UL TRPs. The current 2TA support is not applicable due to the association of each TAG with CoresetPoolIdx (inherent for M-DCI, specified in Rel-18). Since this is an essential component, it is clearly within the scope of objective #5 in Rel-19 MIMO PH5 WID.  In this sense, the support for 2TA for asymmetric DL/UL doesn’t belong to “up-scoping” and therefore doesn’t need any WID update to continue the work in RAN1.  Re the TP proposed in RP-241194, we appreciate and concur with the spirit although the TP requires more discussion in RAN1#118. The current TP not only removes the outcome of Rel-18 MIMO 2TA support (note that 2TA for M-DCI still has many use cases – no reason to remove it from the spec), but is also incomplete. At the same time, the proposal discussed in RAN1#117 suffices at this stage since there is no Rel-19 CR available yet.  [From rapporteur perspective] While it was argued that there is no explicit description on this objective, it can be argued that there is no explicit statement that rules this out either. Such proposals, therefore, must be contribution-driven to be considered in scope – despite the higher priority assigned to topics that are explicitly described in the WID. Given the good progress for asymmetric DL/UL, the support for 2TA warrants timely discussion starting in RAN1#117.  Therefore, we see no need for further RAN action or additional guidance on this issue especially since RAN1 has provided guidance to further study/evaluate this proposal until RAN1#118 for potential adoption. If RAN1 is able to converge in RAN1#118, whether this needs ratification in RAN#105 can be further discussed. |
| Apple | This was proposed as one of the Rel-19 MIMO WID objectives during the Rel-19 MIMO WID discussion. However, this was not agreed to be included in Rel-19 MIMO WID. This is our understanding of the matter of fact. So, strictly speaking, it is out of scope.  However, we have note from the last RAN1#107 meeting “Companies are encouraged to consider above for further discussion in RAN1#118". As results, we are open to keep the topic under discussion in RAN1#118 as study.  We think it is better to have official discussion in September RAN plenary meeting RAN#105 on whether to adopt this as normative objective. |
| **Google** | In our view, 2TA is not within the scope. On the other hand, we acknowledge that 2TA on top of DPS operation can make the system work better for asymmetric DL/UL scenario, but it is not essential. Besides, we failed to see why 2TA on top of any single-DCI based mTRP scheme can help. |
| **New H3C** | From our perspective, 2TA topic should continue discussion under RAN1 and checkpoint should be in RAN#105. |
| **MediaTek** | **Support for 2TAs *for asymmetric DL sTRP/UL mTRP deployment scenarios* was explicitly discussed when defining MIMO scope in the Rel-19 package and left out.**  **This proposal is a clear upscoping and needs discussion in RAN#105 / September 2024 per principle of the Rel-19 package approval.**  **This proposal does have technical merits but it is not the purpose of this offline discussion to discuss these.** |
| **Ericsson** | **In scope of current WID.**  2TA is *technically and commercially essential* for this feature to be useful in practice. Note that the MIMO Phase 5 is clearly targeted at commercially important objectives. Without specifying it means the UL only work in Rel.18 is a paper product and the use of TU so far in RAN1 has been a waste of time. The specification work to include 2TA is very small and we believe features should be specified to the degree that it can realistically be used in practice. |
| ZTE | Firstly, the support of 2TA is an essential functionality for enabling asymmetric DL-sTRP/UL-mTRP, mainly due to it is becoming the bottleneck of UL performance and also the commercial network deployment. From our contribution [R1-2404242], it can be observed that, in a typical scenario, if still being based on a single TA operation, the uplink propagation delay difference of ~70% UE cannot meet the timing error limit Te for both FR1 and FR2. In this sense, it will negatively lead to that the performance of the vast majority of uplink transmissions cannot be guaranteed or the network has to deploy more dense micro nodes.  Then, for the ‘up-scoping’, in our views, introducing 2TA is still **in the objective 5 main bullet**. For R19 WID drafting, it is our understanding that, in RAN1, 2 TA operation is not mandatorily specified, but, any necessary/essential functionality still can be considered in RAN1 as usual, e.g., timeline/CPU occupation for CSI and timeline for UEI beam report. Clearly, per RAN1, the necessity of having 2TA is identified definitely.  After that, for QC’s CR, in general, we tend to agree with the principle of this CR. However, directly removing the condition as proposed in the CR may introduce co-existence/backward-compatibility issues for Rel-18 UE, and then there are still some other related paragraphs in current RAN1 spec (e.g., Section 4.2 in TS 38.213, at well). So we recommend to handle this technical issue in RAN1.  In short, we support two TAs as part of objective 5 in Rel-19 MIMO without any update/up-scoping for the related WID, and, **from RAN perspective, RAN1 discussion about this essential issue in August should be allowed per companies’ contribution**. |
| Futurewei | The objective text does not explicitly include or exclude 2TA though there were some related discussions when R19 MIMO scope was formed. Considering the current situation, we prefer to discuss this along with other up-scoping items in next plenary (RAN#105) |
| **CATT** | In our view, it is out of scope of NR MIMO phase 5. However, since we have a note from RAN1#117 meeting that “Companies are encouraged to consider above for further discussion in RAN1#118", we are open to continue the discussion in RAN1#118. |
| OPPO | As it is captured in RAN1#117 draft report that companies are encouraged to consider 2 TAs for single DCI, we are supportive to study it in R19 MIMO. |
| Docomo | We believe two TA is necessary feature to make asymmetric HetNet scenario works properly, because large propagation delay is expected between UE to DL TRP and UE to UL TRP.  As moderator summarized, in the asymmetric DL sTRP/UL mTRP scenario, there is only one DL TRP, hence it is not possible to reuse Rel.18 Two TA for multi-DCI multi-TRP, which requires two DL TRPs. The necessary spec. impact is very small, as RAN1 discussed the following proposal in RAN1#117:  Proposal 3.1:  To fulfil the asymmetric DL sTRP/UL mTRP deployment scenarios, support two TAs for single DCI based multi-TRP/panel and single TRP.   * Reuse Rel-18 specification of two TA for multi-DCI based multi-TRP/panel and remove the restriction that *coresetPoolIndex* needs to be configured. |
| Spreadtrum | We share the similar view with MTK.  Additional, as the current WID did not set any checkpoint for any scope in future RAN meetings, if this new proposal is going to be discussed in September RAN plenary meeting RAN#105 for Rel-19 package approval, it should be a new WID to fairly compete with those items which had already been on the waiting list. |
| InterDigital | We agree with companies that 2TA is necessary feature to enable UL only TRPs but also agree that this is up-scoping. If allowed, we support to include 2TA enhancement in the WID updates |
| vivo | We are supportive of 2TA for asymmetric UL/DL TRP scenario, from procedure wise we don’t have strong view. |
| Qualcomm | The Plenary should choose one of the following:   * Agree to a TP to implement two TA and not change the WID, and not revisit in RAN#105 * Postpone the decision to RAN#105 and direct RAN1 not to discuss this topic in August. |

# SRS port grouping

SRS port grouping was proposed as a mean to enable the use of 128 ports under TDD system with practical UE implementation in acquiring CSI [1]. UE receiver antenna ports are divided into two low dimensional antenna groups, where each antenna group corresponds to a low dimensional CSI acquisition and PDSCH reception. For example, a UE with 8 RX antenna ports could divide these ports into two groups – 4 RX antenna ports per group. Compared to the case of generating CSI for 8 RX antenna ports, the required UE complexity for generating two sets of CSIs for the two groups of antenna ports (4 RX antenna ports per group) would be reduced.

The companies involved in the RAN1#117 discussion had strong positive views on the support of SRS port grouping in Rel-19. However, there was at least one company who did not agree that this feature is within scope of Rel-19. Given the situation, guidance from RAN1 chair was to further consider SRS port grouping for possible conclusion in RAN1#118.

The moderator requests interested companies to provide their views on the support of SRS port grouping as part of Rel-19 MIMO.

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| **Company** | **Comments** |
| Samsung | The support for SRS port grouping facilitates alignment between a gNB and a UE on the mapping between SRS ports and CWs when >4 DL layers are assigned to the UE in TDD scenario with lower complexity 8RX receiver (comprising two 4RX basebands). Without this mapping, mismatch between the gNB and the UE would affect CQI calculation and result in throughput loss (demonstrated in RAN1#117). Since this proposal relates to the use of 128 ports in TDD scenarios (e.g. C-band, upper FR1) as well as assumption for CQI calculation with RI>4, this is clearly within the scope of objective #2 in Rel-19 MIMO PH5 WID.  Despite the ongoing effort in RAN4 to specify requirements for 8RX UEs (primarily targeted to CPE devices), it is evident that the required complexity for 8RX UEs can be excessive for handheld devices. This roadblock can be circumvented in some cases by the use of 2 4RX basebands and SRS port grouping -requiring *minor spec enhancement*- ensures proper operation in TDD bands.  [From rapporteur perspective] While it was argued that there is no explicit description on this objective, it can be argued that there is no explicit statement that rules this out either. Such proposals, therefore, must be contribution-driven to be considered in scope – despite the higher priority assigned to topics that are explicitly described in the WID. Given the good progress for CSI, the support for SRS port grouping warrants timely discussion starting in RAN1#117.  Therefore, we see no need for further RAN action or additional guidance on this issue especially since RAN1 has provided guidance to further study/evaluate this proposal until RAN1#118 for potential adoption. If RAN1 is able to converge in RAN1#118, whether this needs ratification in RAN#105 can be further discussed. |
| Apple | This was proposed as one of the Rel-19 MIMO WID objectives during the Rel-19 MIMO WID discussion. However, this was not agreed to be included in Rel-19 MIMO WID. This is our understanding of the matter of fact. So, strictly speaking, it is out of scope.  However, we have note from the last RAN1#107 meeting “Companies are encouraged to evaluate for further discussion in RAN1#118". As results, we are open to keep the topic under discussion in RAN1#118 as study.  We think it is better to have official discussion in September RAN plenary meeting RAN#105 on whether to adopt this as normative objective. |
| Google | In our view, how to calculate the CQI for up to 128 ports is naturally within the scope. To calculate the CQI from part of UE ports or all UE ports should be something that needs to be decided.  Further, we also noticed that in Rel-19 RAN1 has already agreed that the NW can configure UE to measure phase offset for CJT from a UE port associated with an SRS port. Based on the same logic and principle, to calculate CQI from a subset of UE ports should be naturally within the scope. |
| **New H3C** | From our perspective, SRS porting group topic should continue discussion under RAN1 and checkpoint should be in RAN#105. |
| **MediaTek** | **Support for SRS port grouping was explicitly discussed when defining MIMO scope in the Rel-19 package and left out.**  **This proposal is a clear upscoping and needs discussion in RAN#105 / September 2024 per principle of the Rel-19 package approval.**  **This proposal does have technical merits but it is not the purpose of this offline discussion to discuss these.** |
| **Ericsson** | **In scope of current WID.**  SRS PG is *essential from a commercial perspective* for up to 8 layer SU-MIMO to be deployed in practice when large antennas is deployed. The MIMO Phase 5 is clearly targeted at commercially important objectives. Currently 8 layer SU-MIMO is not very common in reality and with the additional UE complexity burden to support large antenna signal processing, there is an even larger risk that such 8 layer UE never becomes reality in networks. Hence, we see the SRS PG as an essential and naturally needed component for introduction of large antennas. |
| ZTE | We can support to consider this issue in objective 2 CSI in Rel-19 MIMO, considering that it has a list of supported companies in RAN1 level for reducing the UE complexity of supporting 6/8-layer DL MIMO in UE side. |
| Futurewei | The objective text does not explicitly include or exclude SRS port grouping. Our preference is to let RAN1 continuing the discussion. |
| **CATT** | Since we have a note from RAN1#117 meeting that “Companies are encouraged to consider above for further discussion in RAN1#118", we are supportive to continue the discussion in RAN1#118. |
| OPPO | As it is captured in RAN1#117 draft report that companies are encouraged to further study/evaluate it, we are open to study this issue in R19 MIMO. |
| Docomo | We believe SRS port grouping is in scope of 128 port CSI in Rel-19 MIMO. Without SRS port grouping, some UEs would be difficult to implement rank >4 for 128 port CSI. Supporting SRS port grouping reduces UE complexity to implement rank >4 for 128 port CSI, and it encourages more UEs to implement 128 port CSI. Hence, we believe SRS port grouping is necessary for 128 port CSI with rank >4.  We agree with Moderator’s guidance to continue discussion in RAN1#118. |
| Spreadtrum | We share the similar view with MTK.  Additional, as the current WID did not set any checkpoint for any scope in future RAN meetings, if this new proposal is going to be discussed in September RAN plenary meeting RAN#105 for Rel-19 package approval, it should be a new WID to fairly compete with those items which had already been on the waiting list. |
| Qualcomm | Postpone the discussion to RAN#105 and direct RAN1 not to discuss this topic in August. When port grouping is considered to be added to the MIMO WID, it should be after agreeing the assumed receive architecture and conditioned on studying and finding benefits. |

# Partial-Coherent UL codebook

Current Rel-19 MIMO WID has the following objective on 3TX enhancement:

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*

The proposal in [2] is to additionally support partial coherent UL codebook in addition to the non-coherent UL codebook. From moderator point of view, this is a clear up scoping of the Rel-19 MIMO objectives.

The moderator requests interested companies to provide their views on the support of partial coherent UL codebook as part of Rel-19 MIMO.

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| **Company** | **Comments** |
| Samsung | We agree with the moderator that this clearly belongs to up-scoping discussion (not in RAN#104, can be discussed in RAN#105). |
| Apple | This was proposed as one of the Rel-19 MIMO WID objectives during the Rel-19 MIMO WID discussion. However, this was not agreed to be included in Rel-19 MIMO WID. This is our understanding of the matter of fact. So, strictly speaking, it is out of scope.  We prefer to discuss this topic, if needed, in September RAN plenary meeting RAN#105, and stop discussion in this RAN#104. |
| Google | We also think partial-coherent UL codebook is clearly out of scope. |
| New H3C | partial-coherent UL codebook topic is out of scope and should be discussion in RAN#105 if necessary. |
| **MediaTek** | **This proposal is a clear upscoping and needs discussion in RAN#105 / September 2024 per principle of the Rel-19 package approval.**  **This proposal does have technical merits, but it is not the purpose of this offline discussion to discuss these.** |
| CMCC | We are OK to consider it in next RANP meeting since it is out of scope. |
| **Ericsson** | **Not in scope of the current Rel-19 MIMO objectives but should be added in RAN#105**  **Specification effort and scope:** Unlike fully coherent designs, a partially coherent codebook can be straightforward constructed with minimal meeting time in RAN1 by reusing precoders from the Rel-15 4 Tx codebook, but setting the power of one antenna port to 0 (‘blanking’ the port), which aligns with the 3 Tx design principle of using 3 of 4 SRS ports.  *We propose to specify support for 3 Tx partially coherent precoding by adding 8 partially coherent precoders to the 3 Tx non-coherent codebook that are generated by setting a same row of all 4 Tx precoders to zero (‘port blanking’).*  **Background and technical motivation:** We think the conservative, commercially targeted, approach to define the Rel-19 MIMO phase 5 work was quite important and avoided the over-scoping that can commonly occur in work items. Indeed, it was so successful that the work e.g. on 3TX has been essentially complete since RAN1#116bis, leaving room for some small items that could be completed using the existing MIMO phase 5 time allocations, as discussed in RAN1#117.  The current 3 Tx design essentially requires full power UL MIMO UE implementations in order to have consistent benefits over 2 Tx. The example results below show how 2 Tx UEs actually have better cell edge performance than 3 Tx UEs when Rel-15 based designs with 1/N rated PAs are used for N={2,3} Tx, while partially coherent codebook designs can recover much of the lost performance.  Here, the ‘eMBB’ 3 Tx scenario is used, with the 3 Tx UE having a dual-polarized and a single polarized element (both elements are omnidirectional). Details of the simulations can be found in R1-2405119 and earlier contributions. |
| ZTE | We support the moderator assessment that there is a up-scoping of Rel-19 MIMO objectives. |
| Futurewei | We agree this is an up-scoping of work and should be discussed in next plenary meeting. |
| CATT | It is out of scope. It could be discussed in RAN#105. |
| OPPO | It is up-scoping of R19 MIMO WI.  There are many contributions in RAN1 to show the benefits of partial-coherent codebook and support to specify it. That means there are sufficient justification. Thus, we support to specify 3Tx partial-coherent codebook in R19 MIMO. It should be added in Sept RAN meeting. |
| Docomo | Rel-19 MIMO WID for 3Tx is limited to “Non-coherent UL codebook”, hence “partial coherent UL codebook” is clearly out of scope of Rel-19 MIMO WID. |
| Spreadtrum | We share the similar view with MTK.  Additional, as the current WID did not set any checkpoint for any scope in future RAN meetings, if this new proposal is going to be discussed in September RAN plenary meeting RAN#105 for Rel-19 package approval, it should be a new WID to fairly compete with those items which had already been on the waiting list. |
| InterDigital | For the completeness of the 3Tx UE feature, we think it is essential to have partial coherent UL codebook but agree that it is not part of current R19 scope. |
| vivo | We are open to discuss in RAN#105 and available TU and workload should be carefully assessed. |
| Qualcomm | Postpone decision to RAN#105 and direct RAN1 not to discuss this topic in August. |

# UL precoder cycling

In [3], it is proposed to study open loop based UL precoder cycling scheme to understand its performance benefit and specification impact. From moderator point of view, this is a clear up scoping of the Rel-19 MIMO objectives.

The moderator requests interested companies to provide their views on the support of UL precoder cycling as part of Rel-19 MIMO.

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| **Company** | **Comments** |
| Samsung | We agree with the moderator that this clearly belongs to up-scoping discussion (not in RAN#104, can be discussed in RAN#105).  At the same time, we are supportive of specifying *smaller UL PRG sizes for PUSCH* to enable spec-transparent UL transmit diversity schemes such as UL precoder cycling or small-delay CDD. It is our view that this should be included as high-priority candidate for up-scoping discussion of Rel-19 MIMO PH5 in RAN#105, |
| Apple | This was proposed as one of the Rel-19 MIMO WID objectives during the Rel-19 MIMO WID discussion. However, this was not agreed to be included in Rel-19 MIMO WID. This is our understanding of the matter of fact. So, strictly speaking, it is out of scope.  We prefer to discuss this topic, if needed, in September RAN plenary meeting RAN#105, and stop discussion in this RAN#104. |
| Google | We think UL port cycling is within the scope, but UL precoder cycling could require something more. For codebook based transmission, how to identify the associated SRS ports (including the order for the associated SRS ports) for a PUSCH transmission occasion is an essential issue that needs to be addressed anyway. |
| New H3C | For UL precoder cycling, this topic will extend current Rel-19 MIMO WID scope so it should be discussed in RAN#105 if necessary. |
| **MediaTek** | **This proposal is a clear upscoping and needs discussion in RAN#105 / September 2024 per principle of the Rel-19 package approval.** |
| Ericsson | **Not in scope of the current Rel-19 MIMO objectives and it should not be added in RAN#105. Can be considered for MIMO Phase 6**  This is a substantial up-scoping of the Rel-19 MIMO objectives and requires also studies on other alternatives as well as system level simulation studies with realistic assumptions.  While we acknowledge that uplink robustness is important for NR UL MIMO, and enhancements that can provide gains beyond those mechanisms are already supported in NR specifications and/or possible through implementation merit consideration.  However, frequency selective precoding-based schemes can have strong impacts on channel estimation and interference estimation, which needs to be addressed properly in a larger study.  UL precoder cycling can potentially increase UE PAPR (and therefore decrease coverage). Moreover, such schemes are a strong deviation from Rel-15, since uplink PRGs (and therefore frequency selective precoding) would be defined, which should be considered in a wider context than a small portion of the 3Tx work item or a TEI.  We therefore think further study is needed for UL frequency domain precoder cycling, including the performance gains over frequency hopping based schemes, possibly combined with CDD, etc. Other uplink robustness schemes should also be considered, including enhancements to frequency hopping, etc. |
| ZTE | We support the moderator assessment that there is an up-scoping of Rel-19 MIMO objectives. Then, we can be open to further discuss this enhancement in RAN#105. |
| Futurewei | We agree this is an up-scoping of work and should be discussed in next plenary meeting. |
| OPPO | It is up-scoping of R19 MIMO WI.  It can be discussed in Sept RAN meeting. |
| Docomo | If UL precoder cycling is for 3Tx, Rel-19 MIMO WID does not preclude this direction, hence RAN1 can continue discussion.  If UL precoder cycling is not limited to 3Tx, it is up scoping of Rel-19 MIMO WID, hence it can be discussed in RAN#105. |
| Spreadtrum | We share the similar view with MTK.  Additional, as the current WID did not set any checkpoint for any scope in future RAN meetings, if this new proposal is going to be discussed in September RAN plenary meeting RAN#105 for Rel-19 package approval, it should be a new WID to fairly compete with those items which had already been on the waiting list. |
| InterDigital | This is clearly up-scoping and even lower priority issue compared to other up-scoping topics from our perspective. We can discuss in RAN#105 |
| vivo | We are fine to discuss in RAN#105. We have provided system simulations demonstrating the performance gain for 5 percentile UEs. UL robust transmission is more important than rank>1 transmission in UL as most of the complaints from users in real network comes from the scenarios where the SNR is very low. Real network problem at low SNR region for UL should be addressed to motivate UE vendors to widely implement UL MIMO (multiple RF chains/components), otherwise the UE vendors will never implement UL MIMO. |
| Qualcomm | Postpone decision to RAN#105. |

# Conclusions

Based on the discussions captured in Sections 2, 3, 4, and 5, moderator makes the following observations/proposals.

TBD

# References

[1] R1-2403945 On 128 CSI-RS ports and UE reporting enhancements Huawei, HiSilicon

[2] RP-241207 Views on scope of Rel-19 NR MIMO Phase 5 CMCC

[3] RP-241194 Views on the scope of Rel-19 MIMO WI Qualcomm Incorporated