**3GPP TSG RAN#105**

**Melbourne, Australia, September 9th – 12th, 2024**

**Title: Way Forward on Rel-19 MIMO Scope Expansion**

**Source: RAN1 Chair**

# Introduction

Multiple RAN1 proposals have been proposed to RAN#105 for inclusion as part of Rel-19 MIMO. The following proposals have been proposed:

Table 1. Rel-19 MIMO proposals submitted to RAN#105.

|  |  |  |
| --- | --- | --- |
| **Proposal** | | **Proponents** |
| **A** | SRS port grouping for TDD low-complexity 6/8RX receiver | **RP-241774** Samsung, CMCC, MediaTek, Ericsson, Huawei, HiSilicon, NTT DOCOMO, NTT CORPORATION, ZTE, OPPO, vivo, CableLabs, CATT, China Telecom, China Unicom, Deutsche Telekom, DISH Network, ETRI, Fraunhofer IIS, Fraunhofer HHI, Futurewei, Google, HONOR, Interdigital, KDDI, KT Corporation, Kyocera, LG Electronics, LG Uplus, NEC, New H3C, NICT, Sharp, SK Telecom, Sony, Tejas Networks, Verizon, Vodafone, Xiaomi  **RP-241765** Qualcomm (at least Proposal B, C)  **RP-241895** Intel (at least Proposal B, C) |
| **B** | 2TA without CoresetPoolIdx association for asymmetric DL sTRP/UL mTRP |
| **C** | 3T6R SRS antenna switching |
| **D** | 3T3R SRS antenna switching | **RP-241765** Qualcomm |
| **E** | PRG (precoder granularity) for PUSCH transmission (applicable of CP-OFDM only) | **RP-241819** vivo, Samsung, Spreadtrum, Verizon, Deutsche Telekom, China Unicom, NTT DOCOMO, InterDigital CHTTL |
| **F** | 3-Tx partial-coherent codebook for ranks 1, 2, and 3 | **RP-242029** Ericsson, Qualcomm, InterDigital, NEC, Samsung  **RP-241941** China Mobile (3 TX partial-coherent codebook) |
| **G** | UE capability for non-codebook-based UL transmission |

The purpose of this document is to collect company views on the proposed Rel-19 RAN1 objectives and recommend a way forward.

# WG status on Rel-19 MIMO

Overall, RAN1 progress on Rel-19 MIMO has been good. Even with reduced TUs (2.5 TUs 🡪 2 TUs) starting from Q4, moderator’s assessment (as RAN1 chair) is that the current RAN1 objectives can be completed on time. However, considering the importance of completing Rel-19 on time, a conservative approach is preferred with regards to any up scoping. A proposal should be only considered if it has minimal RAN1 impact (i.e. can be completed within 1~2 meeting cycles without any RAN1 TU increase) and requires no TU increase in other RAN WGs. Additionally, considering there is no additional RAN1 TU for the new proposals, it would not be feasible to have a study phase.

Following is assessment on the required effort to complete the work in RAN1, RAN2, and RAN4.

Table 2. Assessment on required effort to complete the work in RAN1. Assessments for RAN1, RAN2, RAN4 were done by RAN1, RAN2, RAN4 Chairs, respectively.

| **Proposal** | | **Required additional RAN1 effort** | **Required additional RAN2 effort** | **Required additional RAN4 effort** |
| --- | --- | --- | --- | --- |
| **A** | SRS port grouping for TDD low-complexity 6/8RX receiver | Small | Small | Small (Demod perf) |
| **B** | 2TA without CoresetPoolIdx association for asymmetric DL sTRP/UL mTRP | Small | Small | Small (RRM) |
| **C** | 3T6R SRS antenna switching | Small | Small | Small |
| **D** | 3T3R SRS antenna switching | Small | Small | Small (UE RF) |
| **E** | PRG (precoder granularity) for PUSCH transmission (applicable for CP-OFDM only) | Small | Small | Small (Demod perf) |
| **F** | 3-Tx partial-coherent codebook for ranks 1, 2, and 3 | Medium (e.g. codebook, DL control signaling design) | Small | Medium (UE RF, Demod perf) |
| **G** | UE capability for non-codebook-based UL transmission | Small | Small | Small (Demod perf) |

The above assessment has been made under the assumption that study phase for the additional RAN1 objectives is not needed and RAN1 can proceed with discussions on how to support these features. If a study phase is required for an objective, recommendation from the moderator is to not include the objective for Rel-19. Also, although the required effort for each proposal may be small, it does not imply RAN1, RAN2, RAN4 are okay to take ALL proposals. To ensure timely completion of Rel-19 MIMO, moderator recommends minimizing the number of newly approved proposals (if any) in RAN#105.

# Company views on additional RAN1 objectives for Rel-19 MIMO

Companies are invited to share their views on proposals A, B, C, D, E, F, G using Table 3. (No need to additionally indicate support in case your support is already captured in Table 1.)

Table 3. Company views on Rel-19 MIMO proposals submitted to RAN#105.

| **Company** | **Comment** |
| --- | --- |
| Apple | 3T6R ( C ) is already approved in the last RAN#104 meeting and captured as part of Rel-19 RAN4 led RF enhancement WID (RP-241656)  We agree to limit the number of proposals that can be approved. We prefer the following three  B. 2TA extension for single-DCI Multi-TRP  F. Partial coherent codebook based 3Tx PUSCH operation  G. nonCodebook based 3Tx PUSCH operation |
| Ericsson  (Mattias F) | For **F** (3Tx) RAN1, we don’t agree the RAN1 effort is medium, based on the proposed alternatives in the inbox, there is not much room left for creativity, since we reuse the 2Tx/4Tx codebooks. Regarding control signalling. the (partial- + non-coherent) codebooks are nested already; no different principle from Rel-15 so it should be straightforward to design the DCI information. An RRC configuration only is needed beyond that, there is no MAC CE stuff here.    For **F** (3Tx) RAN4, we believe the effort is small or even zero in RAN4, since **for demod** requirements use so far for UL MIMO, only the diagonal precoder (TPMI0) is tested for 3Tx and 4Tx, hence the test makes no difference between non-coherent/partial coherent/coherent. Also, this 3Tx PCCB is optional for UE, no need to define a test for it. Moreover, for **UE RF**, there is no test for partial coherent for 4Tx, not sure why there need to be one for 3Tx?    Ericsson support **also D** (3T3R) since it is a practically useful configuration for a 4RX and 3Tx UE, that allows reciprocity based MIMO using only one OFDM symbol SRS (note that some operators TDD special slot pattern cannot use 3 OFDM symbols needed for e.g. 2T4R antenna switching. Note that the work in RAN1 is basically zero if we support 3T6R, since 3T3R is one SRS resource in the set and 3T6R is two such SRS resources.    **On E**,(UL PRG) we wonder why only demod perf is listed? The frequency selective precoding will impact PAPR of the PUSCH transmission and hence also MPR (i.e. UE RF work is needed). In the current proposal, the precoder cycling is not specified by RAN1, so more RAN4 work is definitely needed. Study is needed on appropriate PRG sizes, probably from both performance/ran1 perspective, as well as implementation / gNB Rx demod perspective.  What ranks are supported for PRG cycling?  Only rank 1? Up to rank 8? |
| Samsung | **Re moderator assessment on the RAN1/2/4 effort for each item and up-scoping recommendation only for “specify(ing)” without “study phase”, we concur on the overall assessment.**  Our **priority** is the **A+B+C as a package** described in the WF x1774 (supported by 40 companies, including almost all companies supporting the other two WFs x1819 and x2029). Note that the necessity for A (SRS PG) and B (2TA) have been demonstrated, evaluated, and well-documented since RAN1#117 (May 2024), including their impacts on **RAN2 and RAN4 workload** (the amount of work doesn’t require TU increase in RAN2/4) – cf. references in x1174 as well as x1965, x2039, and x2101.  Depending on the scope, we can be open to the other lower-priority items (D, E, F, and/or G) **only if** A+B+C are already included in the up-scoping package. **Else**, we don’t see much value in up-scoping and hence would rather see no up-scoping for Rel-19 MIMO Ph5 WI.  Re E, to resolve some concerns from the opponents, it is possible to further limit the scope for e.g. only rank-1 (cf. x2101) and “no enhancement on DMRS and PTRS” (cf. x1819).  Re D, Qualcomm has clarified offline: It is not to support 3T3R SRS antenna switching as a feature to be implemented (**already precluded in RAN1#116**), but to add a UE capability signalling to facilitate the UE notifying the NW that it is “not capable” of reciprocity operation (e.g. TX and RX 3-antenna arrays are separate). In this case, it doesn’t revert any RAN1 decision. Therefore, we are fine if the objective is *worded* as follows:  *Specify UE capability signalling for 3T3R:*   * *Note: This doesn’t require specifying 3T3R SRS antenna switching*   Re F, we have lingering concern on the workload given our experience in Rel-15/18 (as also mentioned by the moderator). This concern is resolved in the WF x2028 since the proposed design is specific and almost final. Alternatively, the following *restriction* can be included in the WID Objective based on the known proposals from Qualcomm and Huawei:  *The rank-1, 2, and 3 partially-coherent precoders are based on the QPSK alphabet and derived from the Rel-15 2Tx full-coherent/4Tx partially-coherent design, with a total of 10 precoders across ranks 1, 2, and 3*   * *Note: The amplitude of the QPSK elements in a rank-3 partial-coherent precoders can be different to equalize transmitted power across layers and Tx ports.* * *Note: Combined with the already agreed 7 non-coherent precoders (cf. RAN1#116), this yields a 17-precoder 3-antenna-port UL codebook* |
| China Telecom | We support the following objectives in **RP-241774**:   * SRS port grouping for TDD low-complexity 6/8RX receiver * 2TA without CoresetPoolIdx association for asymmetric DL sTRP/UL mTRP * 3T6R SRS antenna switching |
| SK telecom | Firstly, we support objectives A, B, C in **RP-241774** as first priority.  Also, we think that objectives F and G are needed for the practical implementation of 3Tx and thus prefer to add the following objectives (F, G) also if possible   * 3-Tx partial-coherent codebook for ranks 1, 2, and 3 * UE capability for non-codebook-based UL transmission |
| MediaTek | First of all, we agree with moderator’s recommendation that the number of newly approved proposals should be limited. As the TUs in RAN2/RAN4 for Rel-19 MIMO are quite limited, approval of multiple proposals still causes a lot of additional workloads even each proposal may require small additional effort.  We therefore prefer to limit the scope expansion to the following topics:   * **On A (SRS port grouping)**, this has been well justified and supported by most of the companies during RAN1 discussion. However, we have concern on 6Rx, and we prefer to remove it from the proposal. This is because whether to support the requirement on more than 4 layers (i.e., 6 layers) is still discussed as part of Rel-19 RAN4 led RF enhancement WID, and SRS port group is proposed to be used for 2 CWs, i.e., more than 4 layers. We don’t see the need to consider 6Rx in this proposal before RAN4 agrees on 6 layers for 6Rx UE. * **On B (2TA)**, this also has been well justified and supported by most of the companies during RAN1 discussion. * **On C (****3T6R)**, it is already captured as part of Rel-19 RAN4 led RF enhancement WID, thus no “additional” RAN4 effort would be needed. * **On D (3T3R)**, we could be fine to ONLY introduce a corresponding UE capability to let UE indicate not supporting of 3T3R if UE supports 3T6R. Other enhancement is not needed. This can be captured in the objective together with 3T6R.   We have concern to support proposals other than above due to larger workload and/or no good justification. |
| Nokia | Our understanding is that the highest priority must be given to finalize original R19 MIMO scope, and any new topics cannot have a negative impact on quality of specifications. Specially considering MIMO will have reduced TUs for the remainder of the release, it is important to manage the workload carefully. Even small items may sum up to significant impact in this context, as suggested by the moderator too.  Hence, we should only consider new proposals in the middle of the release that are 1) critical extensions for features already in scope of R19 MIMO work and 2) new features with urgent commercial need. It is our understanding that any feature with urgent commercial need must be followed with the corresponding RAN4 work as well, otherwise the feature will not be available for deployments in practice. Hence, for any feature to be considered further, the corresponding RAN4 needs to be planned for, and proponents need to indicate more clearly what is the scope of the work. Even if the scope is limited to performance, we need a clear assessment of what is really needed in practice, as otherwise we have a performance item that drags on for a long time, effectively taking time from RAN4 during Rel-20 timeframe.  Some specific comments on the proposals below:   * A: Impacts in RAN1 are clear, though a study phase as suggested by Qualcomm would be useful to understand better the applicability of the technique and to be sure the direction take by RAN1 for standardization is appropriate. The RAN4 impact needs to be better explained, because RAN4 is still studying the spatial channel modelling enhancements to enable proper 8-stream MIMO requirements as well as MU-MIMO demod requirements, the latter not currently available in RAN4. This technique basically requires the combination of high-order MIMO and MU-MIMO, so RAN4 needs to discuss a proper framework for definition of the requirements before the work can be done. This needs to be accounted for when planning the work. * B: This is a critical extension for the asymmetric DL sTRP/UL mTRP work ongoing in Rel-19, and scope is well defined. * C: This has already been agreed to in RAN#104, so it is our expectation that it would remain in scope regardless of this discussion, but it is good to also account for it when considering the increased workload in MIMO. * D: More discussion needed if this is part of the 3T6R work * E: This is a new functionality, and there is little to no consideration on how to define the corresponding RAN4 requirements, though it does require many more considerations, as raised by Ericsson above. RAN1 scope can be limited if further optimizations are avoided, but for example one needs to clarify how this relates with SRS transmission so that link adaptation can be performed adequately at gNB. Overall more clarity is needed for both RAN1 and RAN4 scope.   F, G: RAN1 impact can be higher than for some other features, and hence it would be difficult to consider this one in addition to other functionalities of higher priority from our point of view (e.g. 2TA, SRS TX switching). |
| NEC | Besides the topics we supported (A+B+C as a package and F), we are also open to UL PRG (in case all topics will be supported).  One minor clarification on required additional effort, for 3Tx partial coherent codebook, the needed additional effort in RAN1 is true to be medium, while as we have almost finished the precoders (as shown in Ericsson’s WF), this work can be done in 1-2 meetings, so the final additional effort in future RAN1 meetings can be low.  And for UL PRG, in our understanding, only defining UL PRG value in TS seems not sufficient, to make the feature complete, there may need some additional discussion. So we think the additional effort in RAN1 is better to be medium.  Even all the topics agreed, we think at least in RAN1, no additional TU is needed. And the impact on MAC seems little, current TU in RAN2 also seems OK to accommodate the topics.  If we really need to down-select, our preference is A+B+C as a package and F. |
| Spreadtrum | Aside for proposal E (captured in Table 1), we also support proposal B and proposal C, considering the overall relatively small TU needed for all WGs and supportive by a lot of operators. |
| Huawei, HiSilicon | **A+B+C** is a good compromise and way forward to go, which already supported by super majority companies as shown in RP-241774. So, we support the **package of A+B+C**.  Shared the similar view as Samsung, the other items are low priorityto be discussed if only the majority proposal A+B+C is agreed:  For D (3T3R antenna switching), if only UE capability no other spec impact, we are open for it.  For E (UL-PRG cycling), as we mentioned during online discussion, NW side will be impacted, such as channel estimation (asked for PRG level), interference handling, increasing gNB side complexity. Not sure whether there is some discussion on reciprocity based or TPMI based, and transmission scheme switching. If majority companies asked for it, we need to **restrict the PRG size no less than 24RBs**.  For F (3Tx PCCB), we do not see the urgent commercial deployment required yet. In our understanding, the discussion of UL codebook should be simple and complete solution to avoid much discussion as Samsung mentioned. Then, the RAN4 impact also need to be considered.  For G (Non-codebook), if only with UE capability, it is acceptable for us. |
| Qualcomm | At a risk of repetition, would like say it again that some evaluation for both (A) and (E) would be needed. If one wants to add evaluation for the other items as well, it would be ok.  Would like to also clarify the purpose or 3T3R. 3T3R is being discussed here because 3T3R is a codepoint in the SRS antenna switching capability as the excerpt below shows, even though the use of 3T3R doesn’t actually involve switching. It also doesn’t involve any 3Rx operating mode either.  The most typical use case for 3T3R is for a UE that supports 4Rx and 3Tx. This UE may not support 2T4R antenna switching, or maybe it does support it but the gNB doesn’t want to configure SRS antenna switching because it doesn’t have room to configure two or four SRS symbols with the necessary gap between them. The gNB instead configures a single 3-port SRS resources, which the UE anyhow supports for the purposes for PUSCH transmission, and then the gNB uses the partial knowledge of the channels to 3 Rx antennas (out of the 4) to do the 4Rx DL precoder selection. Pretty much all UEs supporting 3Tx and 4Rx (or 8Rx, 6Rx) are able to support this without any implementation change or effort. The only exception are some devices that use different set of antennas for transmit and receive. This is atypical but the spec must allow for that option as well and to be able to distinguish these devices.  As the excerpt below shows, for a UE with 2Tx and 4Rx, 2T2R is a signalled capability. Similarly for a UE with 3Tx and 4Rx, 3T3R must be a signalled capability.  Lastly, the RAN4 impact for (D) is marked as “small”. We didn’t think there was any actual RAN4 impact but maybe we are missing something.  **[38.306]**  ***srs-TxSwitch, srs-TxSwitch-v1610***  Defines whether UE supports SRS for DL CSI acquisition as defined in clause 6.2.1.2 of TS 38.214 [12]. The capability signalling comprises of the following parameters:  - *supportedSRS-TxPortSwitch* indicates SRS Tx port switching pattern supported by the UE, which is mandatory with capability signalling. The indicated UE antenna switching capability of ′xTyR′ corresponds to a UE, capable of SRS transmission on ′x′ antenna ports over total of ′y′ antennas, where ′y′ corresponds to all or subset of UE receive antennas, where 2T4R is two pairs of antennas. *supportedSRS-TxPortSwitch-v1610*, which is optional to report, indicates downgrading configuration of SRS Tx port switching pattern. If the UE indicates the support of downgrading configuration of SRS Tx port switching pattern using *supportedSRS-TxPortSwitch-v1610*, the UE shall report the values for this as below, based on what is reported in *supportedSRS-TxPortSwitch*.   |  |  | | --- | --- | | ***supportedSRS-TxPortSwitch*** | ***supportedSRS-TxPortSwitch-v1610*** | | *t1r2* | *t1r1-t1r2* | | *t1r4* | *t1r1-t1r2-t1r4* | | *t2r4* | *t1r1-t1r2-t2r2-t2r4* | | *t2r2* | *t1r1-t2r2* | | *t4r4* | *t1r1-t2r2-t4r4* | | *t1r4-t2r4* | *t1r1-t1r2-t2r2-t1r4-t2r4* |   - *txSwitchImpactToRx* indicates the lowest band entry number of the UL group (see *txSwitchWithAnotherBand*) that impacts the DL of this band entry;  - *txSwitchWithAnotherBand* indicates the lowest band entry of the UL group, which is defined as band entries with UL (see NOTE) that impact each other's UL (i.e. SRS TX port switching on any of the cells in the group will impact UL on all the cells in the group). This parameter is absent if an UL group contains only one band entry.  For *txSwitchImpactToRx* and *txSwitchWithAnotherBand*, value 1 means first entry, value 2 means second entry and so on. The UE may include *txSwitchImpactToRx* and *txSwitchWithAnotherBand* for a band entry even if *supportedSRS-TxPortSwitch* is set to 'notSupported' for that band entry. All DL and UL that switch together indicate the same entry number.  The entry number is the band entry number in a band combination. The UE is restricted not to include fallback band combinations for the purpose of indicating different SRS antenna switching capabilities.  NOTE: The band with UL includes a band associated with *FeatureSetUplinkId* set to 0 corresponding to the support of SRS-SwitchingTimeNR. |
| Lenovo, MotM | **Issue A:**  From RAN1 perspective, aside from SRS port grouping, in case of NW implementation-based rank downgrade to ≤ 4, it is not clear whether the UE would receive the PDSCH over one or two UE Rx groups. In the former case, performance degradation occurs, whereas the latter case may need further enhancement. In case this issue is supported, this needs to be captured in the updated WID. We are also OK with QC and Nokia’s suggestion to study the enhancements and the corresponding scope.  **Issue C/D:**  We are fine with including this issue to the WID  **Issue E:**  We also see the potential benefit of this feature, and we are open to discuss. Considering the limited TU and to minimize the RAN1 efforts, we suggest limiting it to non-codebook based UL only in Rel-19, if supported.  **Issue F:**  We agree with Ericsson that this feature may require larger RAN1 efforts based on the listed alternatives in the inbox.  **Issue G:**  We are fine with including this issue to the WID |
| OPPO | We support A/B/C/F   * For F, we think Ericsson does a good assessment for the spec impact for both RAN1 and RAN4. Based on the offline discussion, the group has consensus on the rank-1/2 precoders and the principle for rank-3 precoders. Thus, the spec effort is quite limited   Regarding D (3T3R), we share the same view as Ericsson. If only a UE capability is introduced to indicate that the UE does NOT support 3T3R, then we don’t think any work is needed as the group knows this feature is not supported and no signalling is needed if RAN1 spec doesn’t support 3T3R.  Regarding E(UL PRG), we have two questions for clarification:   * Q1: Whether the DCI-based dynamic indication of PRG size is included in the scope of RP-241819 or not? * Q2: During the offline discussion, I noticed there are two different approaches to implement UL PRGs and different companies have different assumptions on these approaches. Thus, which is the target approach for this objective?   + Approach1: The UL PRG are not applied to SRS resource. For this approach     - What precoder(s) are used for the PUSCH with different PRBs? Do we need to specify some new precoders? Or Just to select some precoders existing in the spec and how to do the selection?     - How does gNB do the link adaptation     - How does UE decide to use cyclic precoding or the indicated TMPI when 1-layer PUSCH is scheduled by DCI?   + Approach2: The UL PRG is applied to SRS resource. gNB will measure the corresponding SRS resource(s) to decide the PUSCH. For this approach,     - To what SRS resource the UL PRG is not applied?     - How to indicate/signal PRG for SRS resource(s)? per SRS resource set, per usage, … ?     - If DCI-based dynamic indication of PRG size is supported (depending Q1), how about the SRS overhead?   Regarding G (non-codebook based PUSCH): we are also fine as only a new UE capability signaling is needed for G. |
| InterDigital | First of all, C has been already agreed in the last RAN meeting, so we don’t need to discuss whether it is in or not. For the rest of items, if down-selection is needed, the following is our priority:  1st priority (supporting necessary functionalities to enable 3Tx UE): C, D, and G   * Regarding D, we are supportive Samsung’s clarification   2nd priority (other items in the Samsung’s WF): A, B   * Good level of support and relatively small impacts on other working groups   We are open for the rest of items if the workload is acceptable with current TU allocation across the working groups. |
| DOCOMO | We support **A+B+C** which are supported by supper majority of companies as shown in RP-241774. We believe these 3 topics are higher priority than other topics.  We are open to add D/E/F/G, if A+B+C are supported and there is still room for addition. Among D/E/F/G, we see value of supporting E to improve UL performance. |

# WF on additional objectives for Rel-19 MIMO

TBD