**3GPP TSG RAN WG1 #104b-e R1-2103953**

**e-Meeting, April 12th – 20th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#5 for multi-beam enhancement: Round 4

**Document for:** Discussion and Decision

## Summary of companies’ inputs

### Issue 1 (Rel.17 unified TCI framework for intra-cell beam management)

Table 1 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** |
| 1.6 | Setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index): In addition to association with UL channel/RS,   * Alt1. The setting of (P0, alpha, closed loop index) is also associated with UL or (if applicable) joint TCI state * Alt2. The setting of (P0, alpha, closed loop index) is included with UL or (if applicable) joint TCI state * Alt3. The setting of (P0, alpha, closed loop index) is neither associated with nor included in UL or (if applicable) joint TCI state * Alt4. The setting of (P0, alpha, closed loop index) is determined as in Rel-16 without enhancement | **Alt1 (11)**: Lenovo, CMCC (PUCCH), Nokia/NSB, NTT Docomo, Spreadtrum, CATT, ZTE, OPPO (PUSCH, PUCCH), Qualcomm, Futurewei  **Alt2 (6)**: IDC, Samsung, Intel (at least PUCCH), Apple, Qualcomm, LGE  **Alt3 (5)**: Fraunhofer IIS/HHI, CMCC (PUSCH – SRI, SRS – SRSResourceSet), Ericsson (for P0 and alpha), Sony,  **Alt4 (5)**: vivo, OPPO (SRS), MTK, Huawei, HiSi |
| 1.7 | Path-loss measurement (PL RS):   * Alt1. PL-RS can be included in UL TCI state or (if applicable) joint TCI state.   + FFS: Whether it is always included or not. If not included, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state. * Alt2. PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state   + FFS: Exact association mechanism   + FFS: Whether it is always associated or not. If not associated, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state * Alt3. The periodic DL-RS used as a source RS for determining spatial TX filter can be used as PL-RS. In case the periodic DL-RS used as a source RS for determining spatial TX filter is not used as PL-RS, reuse Rel.16 procedure with the same signaling structure (MAC CE+SRI field in UL-related DCI) to indicate PL-RS for UL transmission with minimum enhancement (e.g. pertaining to the use for PUCCH, or using default PL-RS)   + PL-RS is not additionally configured in or associated to UL TCI state or (if applicable) joint TCI state * Alt4. UE calculates path-loss based on periodic DL RS configured as the source RS or a periodic QCL-Type-D/spatialRelationInfo source of the source RS in UL TCI state or (if applicable) joint TCI state   + FFS: Whether UE can calculate path-loss based on DL periodic RS for path-loss calculation for UL RS in the UL TCI | **Alt1 (10)**: IDC, Fraunhofer IIS/HHI, Ericsson (if UL RS in TCI state), NTT Docomo, OPPO, Intel (at least PUCCH), Qualcomm, AT&T, LGE  **Alt2 (14)**: Lenovo/MoM, CMCC, NTT Docomo, Huawei, HiSi, Spreadtrum, CATT, ZTE, MTK, Futurewei, Sony, Nokia/NSB  **Alt3 (1)**: vivo  **Alt4 (3)**: Ericsson (if DL RS in TCI state), Samsung, Apple, |

**Table 2: PL-RS**

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| **(New) Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#105-e, further discuss to down select or combine from the following two alternatives for PL-RS (note: the text below is based on the agreed description in RAN1#104-e):   * Alt1. PL-RS is included in UL TCI state (or, if applicable, joint TCI state). * Alt2. PL-RS is associated with (but not included in) UL TCI state (or, if applicable, joint TCI state)   + FFS: Exact association mechanism   In addition:   * Support a UE reporting its capability of whether it expects beam alignment between the PL-RS included in or associated with an UL TCI state (or, if applicable, joint TCI state) and the TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state).   + Beam alignment indicates that the total number of TCI/spatialRelation for the PL-RS and the RS in UL TCI (or, if applicable, joint TCI) should be counted as 1 based on the principle defined in UE FG 2-62. * Depending on the final outcome, FFS on exact association mechanism and whether to support a unified mechanism for the setting of (P0, alpha, closed loop index) and PL-RS, if PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state * FFS whether/when a fallback scheme is needed and, if so, further details * FFS: The total number of maintained PL-RSs per CC * FFS: UE capability for maximum number of active PL-RS across CCs per band |

**Table 3**

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| Mod V00 | Proposal 1.5: Based on previous discussion and some offline discussion I was informed of, the new proposal 1.5 could be a good starting point. It basically builds on the format for the previous 1.5B (from Futurewei) but including some parts from 1.5A without agreeing on a default scheme but with addressing concern from some companies about misalignment between PL-RS and   * **Please share your view** * **Since PL-RS has been discussed since day-1 please be flexible when it comes to less essential (purely style or flavor preference) matters** |
| **Company** | **Input** |
| CATT | Support the proposal. |
| vivo | With the following as our preference:  (**New) Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#105-e, further discuss to down select or combine from the following two alternatives for PL-RS (note: the text below is based on the agreed description in RAN1#104-e):   * Alt1. PL-RS is included in UL TCI state (or, if applicable, joint TCI state). * Alt2. PL-RS is associated with (but not included in) UL TCI state (or, if applicable, joint TCI state)   + FFS: Exact association mechanism   In addition:   * Support a UE reporting its capability of whether it expects beam alignment between the PL-RS included in or associated with an UL TCI state (or, if applicable, joint TCI state) and the TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state).   + Beam alignment indicates that the total number of TCI/spatialRelation for the PL-RS and the RS in UL TCI (or, if applicable, joint TCI) should be counted as 1 based on the principle defined in UE FG 2-62. * For the case when periodic DL RS is configured as the source RS in UL or joint TCI state, the UE estimates path-loss based on the periodic DL-RS provided as a source RS for determining spatial TX filter in UL or (if applicable) joint TCI state * ~~Depending on the final outcome, FFS on exact association mechanism and whether to support a unified mechanism for the setting of (P0, alpha, closed loop index) and PL-RS, if PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state~~ * Support additional UE capability to report whether above PLRS determination mechanism is supported. ~~FFS whether/when a fallback scheme is needed and, if so, further details~~ * FFS: The total number of maintained PL-RSs per CC * FFS: UE capability for maximum number of active PL-RS across CCs per band |
| OPPO | Support the 1.5 |
| Samsung | For progress we can accept this proposal 1.5. |
| MediaTek | Support 1.5 except the FFS for the number of PLRS maintained by UE. Why this issue is re-opened? In previous meeting, it was agreed that at most four PLRSs are maintained by UE simultaneously per CC. If more PLRSs are needed, the use case should be agreed first. We suggest either removing the FFS, or putting the following paragraph agreed by RAN1 in the proposal.   * *NOTE: As in Rel-16, a UE does not expect to simultaneously maintain more than four path-loss estimates per serving cell for all PUSCH/PUCCH/SRS transmissions*    + *FFS: investigate the condition(s) agreed in Rel-17 and, if needed, study whether a UE can simultaneously maintain more than four path-loss estimates* |
| LG | Support the proposal.  To address the MTK’s concern, the suggested modification seems also OK as Futurewei mentioned in email discussion in the following:   * The total maintained PL RS # per CC is no more than 4   + FFS: investigate the condition(s) agreed in Rel-17 and, if needed, study whether a UE can simultaneously maintain more than four path-loss estimates based on UE capability |
| Spreadtrum | Support the proposal. We have similar view as MediaTek, and suggest either remove the FFS or replace it by the Note. |
| ZTE | In our views, we may not need to introduce a new definition of beam alignment, and suggest to clarify it based on RAN1 spec description, like: the PL-RS is the same as TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state). If so, we think that counting RS is clear for FG 2-62. Besides, ‘is’ is too strong, and let’s use ‘can be’.  In addition:   * Support a UE reporting its capability of whether it expects the periodic PL-RS included in or associated with an UL TCI state (or, if applicable, joint TCI state) is the same as TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state). * Depending on the final outcome, FFS on exact association mechanism and whether to support a unified mechanism for the setting of (P0, alpha, closed loop index) and PL-RS, if PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state * FFS whether/when a fallback scheme is needed and, if so, further details * FFS: The total number of maintained PL-RSs per CC * FFS: UE capability for maximum number of active PL-RS across CCs per band |

### Issue 2 (L1/L2-centric inter-cell mobility)

**Table 4**

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| **Proposal 2.1**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * For [periodic, semi-persistent, and aperiodic] reporting, in one reporting instance, depending on NW configuration, beam(s) associated with a non-serving cell can be mixed with that associated with serving-cell   + FFS: whether this applies to periodic and semi-persistent   + FFS: How to report the K beams and corresponding qualities if the Tx power among the non-serving cell and with serving-cell is not the same   + Note: The supported numbers of non-serving cells (in terms of measurement/reporting) have not yet been decided. The above description doesn’t imply only one non-serving cell is allowed to be configured for measurement. Nor does this imply that only one non-serving cell is allowed in one reporting instance.   **Proposal (working assumption) 2.2**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * For L1-RSRP measurement and at least aperiodic reporting, support MAC CE based dynamic activation/deactivation of a subset of higher-layer-configured measurement for non-serving cell SSBs   + FFS: Additionally activated non-serving cell information for SSBs to be measured, or activated non-serving cell SSBs   + FFS: Dynamic (MAC CE and/or DCI) activation for semi-persistent   **Proposal 2.3**: Send LS to RAN4 to ask their views on DL measurement timing assumptions for L1/L2-centric inter-cell mobility and inter-cell mTRP. |

**Table 5**

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| Mod V00 | Proposal 2.1: A few companies argue that mixed SC/NSC report is mainly for aperiodic. Nokia argues that if mixed SC/NSC report is agreed, it should be for P, SP, and AP:   * **Please share your view on the cyan text above on supporting mixed report for P, SP, and AP**   Proposal 2.2: A few companies argue that MAC CE activation of SSBs can be instrumental if at least one maximum K is agreed to be large. But most companies support this feature at least for UE power saving.   * **Would a working assumption be acceptable, which can be confirmed if a large value of max K is supported?**   Proposal 2.3: After a proposal on timing assumption didn’t go through vivo proposed to send an LS to RAN4. **Please share your view on this** |
| **Company** | **Input** |
| CATT | Proposal 2.1: Support the cyan text. We believe this functionality should be supported in Rel.17.  Proposal 2.2: Support the proposal. A working assumption is acceptable.  Proposal 2.3: OK |
| vivo | Support all the three proposals. |
| OPPO | Proposal 2.1: regarding the cyan part, we prefer to agree AP first and FFS on SP and P.  Proposal 2.2 WA is ok  Proposal 2.3: support |
| Samsung | We suggest that proposal 2.1 only considers mixing SC and NSC reports in a single reporting instance, regardless of report type. FFS can be kept for report type  **Proposal 2.1**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * ~~For [periodic, semi-persistent, and aperiodic] reporting,~~ in one reporting instance, depending on NW configuration, beam(s) associated with a non-serving cell can be mixed with that associated with serving-cell   + FFS: whether this applies to periodic, ~~and~~ semi-persistent and aperiodic.   + FFS: How to report the K beams and corresponding qualities if the Tx power among the non-serving cell and with serving-cell is not the same   + Note: The supported numbers of non-serving cells (in terms of measurement/reporting) have not yet been decided. The above description doesn’t imply only one non-serving cell is allowed to be configured for measurement. Nor does this imply that only one non-serving cell is allowed in one reporting instance.   For proposal 2.2, not clear on the intention of “or activated non-serving cell SSBs” NSC SSBs are always transmitted, it is only the measurement reporting that can be activated or deactivated. Suggest to update as: “or ~~activated~~ non-serving cell SSBs”  Proposal 2.3: Support  In the previous rounds, even if there is a strong majority on supporting different timing assumptions between SC and NSC, an agreement could not be made. Perhaps some input from RAN4 can help to progress |
| MediaTek | P2.1: Okay to keep the cyan text, or put all of them for further study, as suggested by Samsung (FFS: Supported time behavior, periodic, semi-persistent, and/or aperiodic)  P2.2: Okay to keep it as WA. However, we would like to clarify the last FFS. Does it intend to study whether dynamic activation is needed for semi-persistent measurement? If so, since RAN1 only agrees NSC SSB for now, we see this study should be opened for measurement RS other than NSC SSB, if supported. Thus, we prefer to revise the FFS as :   * + FFS: Dynamic (MAC CE and/or DCI) activation for ~~semi-persistent~~ measurement RS other than non-serving cell SSB, if supported   P2.3: Okay |
| LG | On Proposal 2.1: We support the cyan text that can be incorporated in the existing CSI framework with NW-triggered reporting.  On Proposal 2.2: The motivation is still unclear to us. We don’t think that updating NSCell ID(s) for beam management is frequently required where one or two NSCell(s) would be considered for a cell-edge UE in general. Hence, it is sufficient to reuse the existing CSI framework. When beam quality of NCS is better than that of SC, gNB would most likely initiate HO to the NSC followed by the corresponding RRC reconfiguration of measurement RSs. If it is for aperiodic reporting, current spec allows selecting a resource set among multiple resource sets by DCI. Why do we need MAC-CE for aperiodic beam reporting? |
| Spreadtrum | Proposal 2.1: Support. We have a clarification issue, does this proposal mean non-serving cell RSRP cannot be reported without serving cell RSRP? If it’s not the case, we suggest to add a note:   * + Note: Depending on NW configuration, beam(s) associated with a non-serving cell can be separately reported.   Proposal 2.2: Fine. The confirmation should depend on the maximum # configured NSC RS supported in spec.  Proposal 2.3: OK. |
| ZTE | Proposal 2.1: We slightly prefer to keep the cyan text.  Proposal 2.2: Support. Regarding LG’s comments, we think that the motivation is how to enable UE measurement dynamically. For instance, for current aperiodic RS reporting + periodic RS as a typical case for NSC, the periodic RS should be mandatorily measured by the UE; otherwise, the UE do not have sufficient time of capturing all periodic RS, e.g., 64 SSBs. Thus we need to consider how to activate the RS measurement  Proposal 2.3: No strong preference, and we can live with either ways. |
| Xiaomi | For proposal 2.1, we are fine with the proposal. And we think for each reporting instance, there are 3 cases: only beam(s) associated with a serving cell, only beam(s) associated with a non-serving cell, or beam(s) associated with a serving cell and a non-serving cell.  For proposal 2.2, we can accept it when the value of max K is large.  For proposal 2.3, we support it. |

### Issue 3 (signaling medium)

**Table 6**

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### Issue 4 (MP-UE)

The previous agreement deals with UE reporting for UE-initiated panel selection/activation. In addition, there are two more types of UE reporting proposed by companies:

* Opt1. UE report on panel-specific information (related to UE capability): Information related to the panels equipped by UE for gNB to configure UL resources accordingly
  + E.g., the total number of DL/UL panels, the max number of antenna ports/layers per panel, maximum achievable EIRP per panel, minimal switching delay between panels
  + Support: Huawei, HiSi, ZTE, LG, MediaTek, Apple, Nokia/NSB
* Opt2. UE report on panel activation/selection status (L1/L2 report): Information related to the change of activated/selected panels to refresh/reset UL measurement at gNB accordingly
  + Support: Huawei, HiSi, CATT (via MAC-CE or with existing UL transmission occasions like RACH), APT/FGI, Fraunhofer IIS/HHI, LG, Qualcomm (updating panel ID for UL resources), Samsung, Sony, NTT Docomo

In addition, some companies propose to extend the Rel-15 SRS resource definition by allowing resources with different number of ports. This is aligned with an agreed assumption that different UE panels can have different number of ports.

In light of the above, the following 3 proposals can be a good starting point for discussion.

**Table 7**

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| **Proposal 4.1**: On Rel.17 enhancements for MPUE, support UE to report panel-specific information as a UE capability. Select from at least the following:   * Information related to the total number of DL/UL panel entities * Information related to the number of antenna ports/layers per panel entity * Information related to the maximum number of resources per panel entity for SRS BM * Information related to maximum achievable EIRP per panel entity * Information related to panel switching delay * Note: above ‘panel entity’ is a logical entity and how to map physical panels to the logical entities is up to UE implementation   **Proposal 4.2**: On Rel.17 enhancements for MPUE, for codebook based UL transmission, support CB based SRS resources with different numbers of ports (e.g. 2 ports+4 ports).   * FFS details (e.g. per resource or per resource set) * Note: the above is not for Rel-16 full power transmission but for Rel-17 panel-specific UL transmission   **Proposal 4.3**: On Rel.17 enhancements for MPUE, support UE to report information related to panel activation/selection status   * FFS on reporting parameter and method (e.g. L1 or L2, updated panel ID for a UL resource (set), etc.) |

**Table 8**

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| Mod V00 | **Please share your views on the above proposals** |
| **Company** | **Input** |
| CATT | Support the proposal. |
| Vivo | Support the first one with following update.  **Proposal 4.1**: On Rel.17 enhancements for MPUE, support UE to report panel-specific information as a UE capability. Select from at least the following:   * Information related to the total number of DL/UL panel entities * ~~Information related to the number of antenna ports/layers per panel entity~~ * ~~Information related to the maximum number of resources per panel entity for SRS BM~~ * ~~Information related to maximum achievable EIRP per panel entity~~ * ~~Information related to panel switching delay~~ * Note: above ‘panel entity’ is a logical entity and how to map physical panels to the logical entities is up to UE implementation   Proposal 4.2 need further study.  Proposal 4.3 support. |
| OPPO | Proposal 4.1: Do not support. As we agreed in last meeting, specification should not be designed in such a way that the UE is required to disclose its antenna implementation. This proposal requires the UE to disclose its antenna implementations. The beam indication is through indicating a RS and the mapping between RS and UE panel/beam is controlled by the UE. Furthermore, whether UE-initiated panel selection need specification support is FFS. Before we make conclusion on that, it does not make sense to discuss UE capability.  Proposal 4.2: Do not support. That looks not part of MB enhancement. Why do we discuss it here?  Proposal 4.3: do not support. There is no use case for UE to report the panel activation/selection information. As agreed in last meeting, the mapping between panel entity and RS is controlled by the UE. We also agreed in last meeting that specification should not be designed in such a way that the UE is required to disclose its antenna implementation. The proposal 4.3 seems to ask the UE to disclose the antenna implementation. |
| MediaTek | P4.1 & P4.3: Even though we believe support of panel-specific UE capability reporting and panel activation/selection status reporting is beneficial for several cases, it would be more appropriate to discuss these issues after spec support of UE reporting for UE-initiated panel selection/activation is agreed. Thus, we suggest the following proposal instead:  **Proposal 4.1**: On Rel.17 enhancements for MPUE, investigate and, if needed, specify the following:   * Support UE to report panel-specific information as a UE capability, for example:   + Information related to the total number of DL/UL panel entities   + Information related to the number of antenna ports/layers per panel entity   + Information related to the maximum number of resources per panel entity for SRS BM   + Information related to maximum achievable EIRP per panel entity   + Information related to panel switching delay * Support UE to report information related to panel activation/selection status of a panel entity * Note: above ‘panel entity’ is a logical entity and how to map physical panels to the logical entities is up to UE implementation * Note: This will depend on the final outcome of UE reporting for UE-initiated panel selection/activation   Regarding whether reporting of panel-related information requires UE to disclose its antenna implementation, we agree with OPPO that this should carefully designed. The design should be similar to TCI state for beam indication but without disclosing how NW implement beamforming.  P4.2: Support. This is beneficial for UE power saving for MP-UE, as agreed as an use case in Rel-17. |
| LG | P4.1/P4.2/P4.3: Support.  Responding to OPPO’s comment on P4.1, please note that this proposal is about antenna ports/layers/resources, which all are logical entities written in the spec so this is not directly revealing UE implementation. Please also note that it is essential for UE to report the required number of antenna ports, layers and resources in LTE/NR, for example, FG2-3(PDSCH layers), FG2-14(CB PUSCH, which includes # of layers and resources), FG2-15(NCB PUSCH, which includes # of layers and resources, resource sets), FG2-30(SRS BM, which includes max number of SRS resources and resource sets), etc. These information are essential for gNB to allocate required DL/UL resources and to set transmission mode. For MPUE, these information such as layers/ports/resources can be different per panel so 4.1 is an essential part in order to support panel selection to our understanding.  Responding to OPPO’s comment on P4.2, the WID clearly says to specify features to facilitate dynamic panel selection and we agreed to assume that different UE panel can have different configuration(e.g. 2 port panel+4 port panel). To support dynamic panel switching between 2 port panel and 4 port panel, gNB need to configure one 2 port CB SRS resource and one 4 port CB SRS resource to the UE. Without the proposal, we cannot support dynamic panel switching for this type of UE.  Responding to OPPO’s comment on P4.3, this proposal does not intend to reveal UE implementation to our understanding. As well described in CATT’s contribution, gNB needs to refresh/reset the UL measurement when UE switches its Tx panel for a same resource transmission, resulting from the agreed UE initiated panel activation/selection. |
| Spreadtrum | It seems difficult to make progress without the same understanding on this feature. We suggest to first discuss and clarify the potential impact of switching a panel which is associated with an active TCI state. For example, whether UE can deactivate the corresponding panel without switching to an active panel for an active TCI state? If not, is there any impact when UE switch to another active panel?  For proposal 4.2, we think it should not be discussed here. Maybe in agenda 8.1.3? |
| ZTE | Support all of them. MTK’s revised version about P4.1 seems to be a good way-forward solution. |
| Xiaomi | For proposal 4.1 and 4.3, we are fine.  For proposal 4.2, it can be discussed after proposal 4.1. |

### Issue 5 (MPE mitigation)

# References

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| 1 | R1-2103830 | Moderator summary for offline discussion on multi-beam enhancement: SSB and SRS as QCL Type-D source RS | Moderator (Samsung) |
| 2 | R1-2103220 | Moderator summary for multi-beam enhancement | Moderator (Samsung) |
| 3 | R1-2103854 | Moderator summary#2 for multi-beam enhancement: Round 1 | Moderator (Samsung) |
| 4 | R1-2103892 | Moderator summary#3 for multi-beam enhancement: Round 2 | Moderator (Samsung) |
| 5 | R1-2103930 | Moderator summary#4 for multi-beam enhancement: Round 3 | Moderator (Samsung) |