**3GPP TSG RAN WG1 #107-e R1-2112680**

**e-Meeting, November 11th – 19th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#3 for multi-beam enhancement: ROUND 2

**Document for:** Discussion and Decision

## Introduction

In this summary, the term “item 1” refers to the first item in the Rel.17 NR FeMIMO WID, i.e. multi-beam enhancement:

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| 1. Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:    1. Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management for intra-cell and inter-cell scenarios to support higher UE speed and/or a larger number of configured TCI states:       1. Common beam for data and control transmission/reception for DL and UL, especially for intra-band CA       2. Unified TCI framework for DL and UL beam indication       3. Enhancement on signaling mechanisms for the above features to improve latency and efficiency with more usage of dynamic control signaling (as opposed to RRC)       4. For inter-cell beam management, a UE can transmit to or receive from only a single cell (i.e. serving cell does not change when beam selection is done). This includes L1-only measurement/reporting (i.e. no L3 impact) and beam indication associated with cell(s) with any Physical Cell ID(s)          1. The beam indication is based on Rel-17 unified TCI framework          2. The same beam measurement/reporting mechanism will be reused for inter-cell mTRP          3. This work shall only consider intra-DU and intra-frequency cases    2. Identify and specify features to facilitate UL beam selection for UEs equipped with multiple panels, considering UL coverage loss mitigation due to MPE, based on UL beam indication with the unified TCI framework for UL fast panel selection |

This summary includes the following:

* Observation and proposal
* Summary of current companies’ positions on each of the aspects within the category

## Summary of companies’ inputs

### Issue 1 (Rel.17 unified TCI framework – note: for intra-cell beam management unless otherwise noted)

Table 1 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** |
| 1.1 | **Proposal 1.A.1**: On Rel-17 unified TCI framework, any SRS resource or resource set that is a valid target signal of a Rel-15/16 spatial relation based on the Rel-15/16 spatial relation rules (on source-target relations) can be configured as a target signal of a Rel-17 UL or, if applicable, joint TCI (hence the Rel-17 UL or, if applicable, joint TCI state pool).   * Note: This does not imply that DL and UL TCI state pools are separate or shared for separate DL/UL TCI (this issue is up to RAN2)   **FL Note**: Discussed offline [1] | **Support/fine**: Sony, Nokia/NSB, Ericsson, Samsung, MTK, Fraunhofer IIS/HHI, CMCC, Futurewei, Intel, vivo, NEC, AT&T, NTT Docomo, QC, CATT, Xiaomi, LG, TCL, Lenovo/MotM, Convida, Huawei, HiSi  **Concern**: OPPO, ZTE  **Objected by**: OPPO |
| 1.2 | **Proposal 1.A.2**: On Rel-17 unified TCI framework, for any SRS resource or resource set that does not share the same indicated Rel-17 TCI state(s) as dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources, but can be configured as a target signal of a Rel-17 UL or, if applicable, joint TCI (hence the Rel-17 UL or, if applicable, joint TCI state pool), Rel-17 mechanism(s) which reuse mechanisms similar to the Rel-15/16 spatial relation info update signaling/configuration design(s) are used to update/configure such SRS(s) with Rel-17 UL or, if applicable, joint TCI state(s).   * Applies for both intra-cell and inter-cell beam indication * Note: It is up to RAN2, if needed, to design MAC-CE signaling for the Rel-17 mechanism(s) which reuse mechanisms similar to the Rel-15/16 spatial relation info update signaling/configuration design(s) * [All the Rel-17 UL or, if applicable, joint TCI states configured/activated to SRS resources in the same set are associated with the same UL PC setting]   **FL Note**: Discussed offline [1] | **Support/fine**: Sony, Nokia/NSB, Ericsson, Samsung, MTK, Fraunhofer IIS/HHI, CMCC, Futurewei, Intel, NEC, AT&T, NTT Docomo, QC, CATT, Xiaomi, [Apple], LG, TCL, Lenovo/MotM, Convida  **Concern**: OPPO, ZTE  **Objected by**: [OPPO] |
| 1.3 | **Proposal 1.A.3**: The UE is not expected to be configured with Rel-15/Rel-16 TCI/SpatialRelationInfo if the UE is configured with Rel-17 TCI in any CC in a band  **FL Note**: Discussed offline [1]. Suggest to remove brackets around [in a band] and remove the bullet. | **Support/fine**: Nokia/NSB, Ericsson, Samsung, Apple, MTK, Fraunhofer IIS/HHI (remove bullet), CMCC, Futurewei, vivo, NEC, AT&T, QC (remove bullet), CATT (remove bullet), Xiaomi, TCL, Lenovo/MotM (remove bullet), Convida, NTT Docomo (concern without bullet or without “in a band”), Sony (if “in a band” is kept), Intel (ok “in band”, not ok with bullet)  **Concern**: OPPO  **Objected by**: [OPPO] |
| 1.4 | **Proposal 1.E:** On Rel.17 unified TCI framework, for Rel-17 unified TCI, for DL channels/signals that share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH/PDCCH (via Rel-17 MAC-CE/DCI TCI state update), the following option on source RSs and QCL-Types is also supported:   * Option 3: CSI-RS for CSI is configured for QCL-TypeA and QCL-TypeD source RS   **FL Note**: It was explained that the so-called “circular” issue is avoided in practice via NW implementation, i.e. NW will not configure the same CSI-RS for CSI both as source and target RSs. | **Support/fine (23)**: Huawei/HiSi, Ericsson, CMCC, Samsung, Sony, Qualcomm, Fraunhofer IIS/HHI, Futurewei, MTK, NTT Docomo, AT&T, Lenovo/MotM, Intel, Xiaomi, CATT, TCL, ZTE  **Concern**: Apple (object), OPPO, Nokia/NSB |
| 1.5 | **Working Assumption**  For Rel-17 unified TCI framework, on applying the indicated Rel-17 TCI state to PDCCH reception and the respective PDSCH reception, for intra-cell and inter-cell BM, support per CORESET determination as follows:   * For any PDCCH reception on a CORESET [other than CORESET#0] that is associated with [at least or only] [USS and/or CSS type 3] set(s) and the respective PDSCH reception, UE always applies the indicated Rel-17 TCI state. * For any PDCCH reception on [CORESET#0 or] a CORESET [(other than CORESET#0)] that is not associated with any [USS and/or CSS type 3] set and the respective PDSCH reception, whether or not UE to apply the indicated Rel-17 TCI state is determined per CORESET by RRC   + Note: It was agreed that a UE can receive non-UE dedicated signal/channel only from the serving cell   + Above applies only for intra-cell beam indication * [For inter-cell beam indication, a UE may expect that a CSS and a USS are not associated with a same CORESET]   **FL Note**: 3 open issues to finalize | **CORESET#0:**   * **Remove brackets (include): ZTE, Ericsson** * **Keep brackets (FFS and address in maintenance): QC, Apple, MTK**   **USS and/or CSS Type 3:**   * **Only USS: QC, Ericsson** * **USS and CSS Type 3: Apple, ZTE**   **CORESET association with both CSS and USS:**   * **For both intra- and inter-cell: Ericsson** * **Only for intra-cell:** * **Not supported: QC, ZTE(except for CORESET#0), MTK** |

Table 2 Additional inputs: issue 1

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| **Company** | **Input** |
| Mod V0 | 1. **Check and update your view in Table 1** 2. **Share more inputs here if needed**   **FL comment:**   * **The concerns on 1.A.1/2/3 should have been resolved with the 3rd bullet in 1.A.2 (**All the Rel-17 UL or, if applicable, joint TCI states configured/activated to SRS resources in the same set are associated with the same UL PC setting**)** * **Re Nokia’s concern on 1.E, there mihht be some misunderstanding from Nokia since Opt3 is actually supported in Rel-15/16 QCL rule as repeatedly pointed out by the proponents** |
| Qualcomm | For the 3 open issues in 1.5:   * For COREESET #0, we share the same view as Apple that it can be configured for both CSS and USS. We suggest no such restriction, i.e. the proposal should be applicable to all CORESETs in general. Prefer to remove the text or at least keep the brackets * For Type3 CSS, we prefer to only keep USS, i.e. all CSSs should be counted as non-UE dedicated. But can also be flexible on this issue * For CORESET association with CSS/USS, we prefer to have same CORESET associated with either USS or CSS for both intra and inter-cell as compromise. Ideally, we believe per SS is the most straightforward way to align with the previous agreement. The operation rule should also be simple: Same CORESET can use the indicated R17 TCI if associated with USS, and share the same indicated R17 TCI or use a different TCI indicated by R15/16 signaling if associated with CSS. |
| Intel | **Issue 1.5:** We prefer the following version:  **Working Assumption**  For Rel-17 unified TCI framework, on applying the indicated Rel-17 TCI state to PDCCH reception and the respective PDSCH reception, for intra-cell and inter-cell BM, support per CORESET determination as follows:   * For any PDCCH reception on a CORESET ~~[~~other than CORESET#0~~]~~ that is associated with ~~[at least or~~ only~~] [~~USS and/or CSS type 3~~]~~ set(s) and the respective PDSCH reception, UE always applies the indicated Rel-17 TCI state. * For any PDCCH reception on ~~[~~CORESET#0 or~~]~~ a CORESET ~~[(other than CORESET#0)]~~ that is not associated with any ~~[~~USS and/or CSS type 3~~]~~ set and the respective PDSCH reception, whether or not UE to apply the indicated Rel-17 TCI state is determined per CORESET by RRC   + Note: It was agreed that a UE can receive non-UE dedicated signal/channel only from the serving cell   + ~~Above applies only for intra-cell beam indication~~ * ~~[For inter-cell beam indication, a UE may expect that a CSS and a USS are not associated with a same CORESET]~~   The reasoning is as follows:   * 1st sub-bullet CORESET#0 can be configured with both USS and CSS. So, we prefer to keep the text in the first bracket and remove the brackets. We also prefer to have “only” in the second bracket and remove the brackets. USS and CSS Type 3 should be treated with similar priority since Type 3 CSS is UE specifically configured and C-RNTI is monitored in CSS Type 3. With keeping “only” in the first sub-bullet we do not think the third sub-bullet is necessary since it introduces the additional constraint that CORESET#0 cannot be configured with CSS in the serving cell. We think CORESET#0 is configured from the serving cell PCID and hence do not see why such restriction should be placed on serving cell. * For the second sub-bullet, our understanding is that it covers the case of intra-cell beam indication as well common control and/or UE non-dedicated reception from the serving cell during inter-cell beam management. Therefore, we should delete the sub-bullet restricting it for the case intra-cell BM only. We think that the note clarifying restriction on non-UE dedicated signal/channel is enough to capture agreed behavior. With the second sub-sub-bullet, we seem to leave out the case for non-UE dedication signal/channel reception from the serving cell during inter-cell beam management.   We also note that specifying beams per CORESET follows current behavior and would lead to minimal specification impact rather than per SS beam assumptions. |
| Lenovo/MotM | Proposal 1.A.2: Regarding the note on SRS UL PC setting in square bracket, we think it is essential for the proposal to work. The bracket should be removed.  Issue 1.5: It is clear to remove the bracket for the third bullet to clarify the case of inter-cell beam indication. The bracket should be removed. After this is done, it is clear that the first two bullets only apply to intra-cell. |
| Apple | 1.A.1: We suggest we add a new bullet to clarify this does not require to introduce a new source RS as we agreed for UL/Joint TCI.  1.A.2: We think to maintain set level PC is important. So we have strong concern if the last bullet is removed. Besides, we think this feature should be optional.  1.A.3: We have concern to keep “in a band”. The mixture of R16/R17 beam indication framework in CA would be complicated from UE implementation perspective. R16 supports a multi-CC beam indication, which can be applicable for inter-band CA. R17 supports TCI state pool sharing, which can also be applicable for inter-band CA. If possible, we can also defer the decision (we assume it has no RRC impact), and we can make a decision later to see how much impact there would be for other features if we go with one way or the other.  1.5: We would like to clarify the issue for Type3 CSS.  PDCCH/PDSCH associated with C-RNTI can be transmitted by Type3 CSS. If we say Type3 CSS cannot share the indicated TCI, that means we would have to introduce the MAC CE + DCI based beam indication scheme in R16. Then we need to interpret the TCI as the R16 mechanism. But SSs can have some overlap, which means even after UE decoding the PDCCH, UE does not know whether it belongs to Type3 CSS or USS. Then how to interpret the TCI in DCI becomes a problem.  We think the last bullet is important, not only for intra-cell but also for inter-cell. Otherwise, the outcome will revert agreements. But the last bullet should be for USS/Type3 CSS and other CSS. One question to FL, shall we put our name under both intra and inter-cell or not supported? The sentence seems to suggest one CORESET cannot be associated with both CSS and USS.  **CORESET association with both CSS and USS:**   * **For both intra- and inter-cell:** * **Only for intra-cell:** * **Not supported: QC** |
| ZTE | **Issue 1.5:** We prefer the following version:  **Working Assumption**  For Rel-17 unified TCI framework, on applying the indicated Rel-17 TCI state to PDCCH reception and the respective PDSCH reception, for intra-cell and inter-cell BM, support per CORESET determination as follows:   * For any PDCCH reception on a CORESET other than CORESET#0 that is associated with only USS and/or CSS type 3 set(s) and the respective PDSCH reception, UE always applies the indicated Rel-17 TCI state. * For any PDCCH reception on CORESET#0 or a CORESET (other than CORESET#0) that is not associated with any USS and/or CSS type 3 set and the respective PDSCH reception, whether or not UE to apply the indicated Rel-17 TCI state is determined per CORESET by RRC   + If not, the corresponding TCI state is updated by Rel-17 mechanism that reuses Rel-15/Rel-16 TCI activation signaling.   + Note: It was agreed that a UE can receive non-UE dedicated signal/channel only from the serving cell   The corresponding technical reason are provided as follows:   * For CORESET#0, regardless of being associated with USS, the UE behavior should be handled by legacy Rel-15/16 rule in our views. Then, we have a specific Rel-15 MAC-CE command for handling CORESET#0’s TCI update. Then, for CSS Type#3, we identify very similar UE behavior for USS, and so we prefer to introduce CSS Type#3 with USS together. * For second bullet, based on online discussion, the controversial part is relevant to how to achieve the dynamic switching between intra/inter-cell. So, we prefer to clarify the case that if no applying the Rel-17 TCI state, we reuse the Rel-15/16 signaling. Based on that, this bullet applies to inter-cell beam management, and in such case, we believe that the corresponding RRC configuration should be ‘No’.   Then, the last bullet can be removed accordingly. |
| MediaTek | On Proposal 1.A.3, we think this is important since this will impact **both RAN2 RRC design for Rel-17 unified TCI framework (e.g., whether to reuse the legacy TCI-list or not) and UE feature discussion**.  We see so far the controversial parts are:   * Whether to include SpatialRelationInfo, this will depend on Proposal 1.A.1 and Proposal 1.A.2. * Whether to include in a band, even we think this is not needed, however, we can check this after UE feature has some conclusions.   One possible way is we can put the two controversial parts in brackets and resolved them in the maintenance stage.  For the 3 open issues in 1.5   * Whether CORESET#0 need special handing? IMO, this will depend what’s the final result of 1st and 2nd sub-bullets. For example, if the “at least” is agreed for the 1st sub-bullet instead of “only”, then we will prefer to keep “other than CORESET#0” since it is not reasonable to require CORESET#0 to follow a TCI stare associated with NSC for inter-cell case. In summary, we suggest to keep it in the brackets and resolve it after other parts are stable. * Whether CSS Type 3 need to be consider as UE-dedicated? No strong preference. * Whether CORESET can be associated with both CSS and USS? Even we don't see this will violates any previous agreements (RAN1 agreements prevent the configuration instead of confirmation mechanism), we are fine to preclude it for both intra- and inter- cell operations.   In summary, we prefer the following. Regarding 2nd sub-bullet, we don't think it is only applicable for intra-cell case. The following note already implies configuring the CORESET associated with CSS only to apply the indicated Rel-17 TCI state is not allowed.  **Working Assumption**  For Rel-17 unified TCI framework, on applying the indicated Rel-17 TCI state to PDCCH reception and the respective PDSCH reception, for intra-cell and inter-cell BM, support per CORESET determination as follows:   * For any PDCCH reception on a CORESET [other than CORESET#0] that is associated with ~~[at least or~~ only~~]~~ [USS and/or CSS type 3] set(s) and the respective PDSCH reception, UE always applies the indicated Rel-17 TCI state. * For any PDCCH reception on [CORESET#0 or] a CORESET [(other than CORESET#0)] that is not associated with any [USS and/or CSS type 3] set and the respective PDSCH reception, whether or not UE to apply the indicated Rel-17 TCI state is determined per CORESET by RRC   + Note: It was agreed that a UE can receive non-UE dedicated signal/channel only from the serving cell   + ~~Above applies only for intra-cell beam indication~~   ~~[For inter-cell beam indication, a UE may expect that a CSS and a USS are not associated with a same CORESET]~~ A UE doesn't expect that a CORESET is associated with USS and CSS |
| Nokia/NSB | **1.A.1:** support  **1.A.2:** ok. It might be worth indeed wo agree on the PC parameters and hence remove the brackets on the last bullet  **1.A.3:** ok.  **1.E:** after more analysis, we are OK. |
| Ericsson | Proposal 1.A.1: Support  Proposal 1.A.2: Support  Proposal 1.A.3: Support  Issue 1.5:   * CORESET#0 is in most cases similar to other CORESETs. We see no reason to treat it differently. * RAN1 made a statement on “non-UE-dedicated” signals. The disagreement on this aspect is on how to define “UE-dedicated”. There are two views: define based on search space type or based on the RNTI. As we see it, search space type is more applicable physical layer, whereas RNTI is defined in 38.321. Hence, search space type is the relevant property, implying that “UE-dedicated” signaling is USS.   RAN1 cannot introduce general restrictions on how CORESETs and search spaces are defined. Such exceptions go far beyond MIMO. What we are discussing here is QCL assumptions, and those can be captured in TCI state limitations. |
| Xiaomi | For issue 1.5  For [at least or only], we prefer to keep “at least”. Since CSS set can share same TCI state as USS set. If there is a CORESET associated with both CSS set and USS set, gNB should configure the CSS set to share same TCI state as the USS set. If the CSS set can’t share same TCI state as the USS set, it will be not configured to associate with a same CORESET as the USS set.  For [USS and/or CSS Type 3], we prefer to keep “USS” only, while for CSS Type 3, RRC configuration can be used to configure it.  For [CORESET#0 or] a CORESET [(other than CORESET#0)], we prefer to remove [CORESET#0 or] and [(other than CORESET#0)].  For the last bullet, we are fine to keep it. |
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### Issue 2 (inter-cell beam management)

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### Issue 3 (signaling medium)

Table 5 Summary: issue 3

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| **#** | **Issue** | **Companies’ views** |
| 3.1 | **Proposal 3.B**: Refine the following agreement as follows:  Agreement  On Rel-17 DCI-based beam indication, regarding application time of the beam indication, the UE is configured with at least one beam application time (BAT) ~~[~~per BWP per CC~~]~~   * Note: It was agreed that the BAT associated with the carrier(s) (hence BWP(s)/CC(s)) on which the beam indication applies is determined on the carrier with the smallest SCS among the carrier(s) (hence BWP(s)/CC(s)) applying the beam indication * TBD (RAN1#107-e): whether a second configured BAT is also supported, e.g. for MPUE or inter-cell BM, [per BWP per CC] * ~~TBD (RAN1#107-e): Whether or not t~~The UE may assume that BWPs configured with same SCS ~~[in a same CC group]~~ share a same value of BAT   **FL Note**: This is the current situation  One BAT per BWP per CC, no constraint:   * **Support/fine**: ZTE, Qualcomm, Ericsson, Intel, Nokia/NSB * **Concern**:   One BAT per BWP per CC, BWPs with same CSC (in a same CC group) share a same BAT (yellow):   * **Support/fine**: Samsung, Sony, OPPO, Apple, MTK, NTT Docomo, Xiaomi, vivo, Intel, Lenovo/MotM * **Concern**: | **Support/fine**: Samsung, Sony, OPPO, Apple, MTK, NTT Docomo, Xiaomi, vivo, Intel, Lenovo/MotM, QC  **Concern**: |

Table 6 Additional inputs: issue 3

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| **Company** | **Input** |
| Mod V0 | 1. **Check and update your view in Table 5** 2. **Share more inputs here if needed** |
| Qualcomm | Fine with Proposal 3.B |
| Intel | Ok with 3.B |
| Lenovo/MotM | Support Proposal 3.B. |
| Apple | We think to configure it in serving cell group level is cleaner.  We found one comment from MTK that serving cell group may not be configured. We are not sure whether that is true. But in our view, BAT should be optionally configured, and when it is not configured, the UE reported value is used. Is that common understanding? |
| ZTE | Fine except for last bullet. In our views, we do not need to discuss the error cases herein, and suggest to remove it. Otherwise, we may consider per cell group for simplify. |
| MediaTek | Support the proposal.  @Apple, the cell group to my understanding here is the cell group configured with common TCI state ID activation and indication across a set of “configured” CCs. It is natural NW can decide whether to configure the set(s) of CCs even the cross-CC common beam operation is a basic feature in Rel-17 unified TCI. |
| Nokia/NSB | 3.B.: support. One the two alternatives highlighted by the FL, we find the second one as a more detailed configuration, that is the BWPs with same SCS (BTW, there is typo in the proposal on the acronym) share the same BAT, we do not see critical to agree on this point for now, in any case, if we open that discussion, we need a solution for the case where different SCSs are used. |
| Ericsson | Like ZTE, we are fine except for the last bullet. The specification should not restrict NW configuration – it would seem that if there is such a restriction, the parameter is defined on the wrong place. Cell group is not correct either, this would lead to unnecessary limitations. Usually, if inconsistent RRC parameters are signalled to the UE, the behavior is up to UE implementation. (My RAN2 colleagues even say that the UE may explode.) How about making this explicit, and also handle the case with different SCSs:  Agreement  On Rel-17 DCI-based beam indication, regarding application time of the beam indication, the UE is configured with at least one beam application time (BAT) ~~[~~per BWP per CC~~]~~   * Note: It was agreed that the BAT associated with the carrier(s) (hence BWP(s)/CC(s)) on which the beam indication applies is determined on the carrier with the smallest SCS among the carrier(s) (hence BWP(s)/CC(s)) applying the beam indication * TBD (RAN1#107-e): whether a second configured BAT is also supported, e.g. for MPUE or inter-cell BM, [per BWP per CC] * ~~TBD (RAN1#107-e): Whether or not tThe UE may assume that BWPs configured with same SCS [in a same CC group] share a same value of BAT~~ * Note: If the NW configures BATs resulting in different beam update timing for CCs configured for common TCI update, the behavior is up to UE implementation. |
| Xiaomi | Support |

### Issue 4 (MP-UE)

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# References

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| 1 | R1-2111716 | Summary of offline discussion on unified TCI, inter-cell beam management, and MPUE | Moderator (Samsung) |