**3GPP TSG RAN WG1 #105-e R1-210xxxx**

**e-Meeting, May 10th – 27th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary for multi-beam enhancement: ROUND 4

**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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| * Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:   + Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management to support higher intra- and L1/L2-centric inter-cell mobility 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)   + 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

The listed issues are structured primarily to facilitate some progress on pending issues identified in the agreements (see Appendix A).

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

UL PC

**Proposal 1.1A:** On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, for PUSCH and PUCCH, the setting is either included in UL TCI state or (if applicable) joint TCI state or associated with UL TCI state or (if applicable) joint TCI state.

* Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed and the signaling) is up to RAN2

Note: It has been agreed that the setting of (P0, alpha, closed loop index) is associated with UL channel or UL RS (therefore the setting is channel- and signal-specific)

**OR**

**Proposal 1.1B:**On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework,

* For each of PUSCH and PUCCH, the setting of (P0, alpha, closed loop index) can be associated with UL or (if applicable) joint TCI state.
  + In this case, multiple settings are configured. Each setting can be associated with at least one TCI state, and, for a given TCI state, only one setting for PUSCH and only one setting for PUCCH can be associated at a time.
  + Details of the association (including the manner it is performed and the signaling) is up to RAN2
* If not associated, for each of the PUSCH and PUCCH, the setting(s) of (P0, alpha, closed loop index) per channel/signal is independent the UL or (if applicable) joint TCI states
* FFS: If SRS can also be associated with UL or (if applicable) joint TCI state.
* FFS: (to be decided in RAN1#106-e) whether to configure the same setting of (P0, alpha, closed loop index) per TCI state across channels and apply a channel dependent component, or configure a channel dependent setting of (P0, alpha, closed loop index) per TCI state

Table 1 Additional inputs: issue 1 – UL PC

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **(Last attempt per Mr. Bo’s request) Since technical arguments have been made, please complete the following. If you want to present some new or summarize your arguments, or suggest a compromise, please use the rows below:**  **Proposal 1.1A:**   * **Support: Samsung, ZTE, LG, OPPO, Qualcomm (1st), MTK** * **Concern: ...**   **Proposal 1.1B:**   * **Support: Apple, Samsung, ZTE, LG, OPPO, Qualcomm (if SRS is included), MTK** * **Concern: ...**   **If there is no consensus in selecting either 1.1A or 1.1B (or a compromise between the two acceptable to all), the proposed conclusion in the chairman notes will be the outcome.** |
| Apple | We are ok with majority view – 1.1B. |
| LG | For a sake of progress, either 1.1A or 1.1B is fine for us. |
| OPPO | Either 1.1A and 1.1B is ok to us. |
| Qualcomm | We can live with 1.1B if SRS can be included in PUSCH/PUCCH in 1st bullet. This may not be optimal signaling, but it should work to our understanding. We prefer not to spend more time on this topic as compromise. |
| Docomo | Either 1.1A or 1.1B is fine for us. |
| NEC | Either 1.1A or 1.1B is fine. |
| Xiaomi | Either 1.1A or 1.1B is fine to us.  Maybe a small typo in 1.1B, “If not associated, for each of the PUSCH and PUCCH, the setting(s) of (P0, alpha, closed loop index) per channel/signal is independent of the UL or (if applicable) joint TCI states” |

M>1 or N>1 support:

**Proposal 1.2**: On Rel-17 unified TCI, in RAN1#106-e, for M>1 and/or N>1:

* Identify and agree on use cases
* Identify feasible candidate schemes for beam indication signaling mechanism (including TCI state activation)
* Decide whether to support M>1 and/or N>1, and if so, the maximum value of M and/or N

Table 2 Additional inputs: issue 1 – M/N>1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your input on the above proposal** |
| Apple | Use cases: mTRP only and we have strong concern to use it for sTRP  Beam indication signaling mechanism: TCI codepoint mapped to 2 DL/UL TCI or 2 joint TCI  Maximum value: M=2, N=2 |
| Samsung | In general, fine with proposal, but we would like to reorder bullet 2 and 3  **Proposal 1.2**: On Rel-17 unified TCI, in RAN1#106-e, for M>1 and/or N>1:   * Identify and agree on use cases * Decide whether to support M>1 and/or N>1, and if so, the maximum value of M and/or N * If supported, identify feasible candidate schemes for beam indication signaling mechanism (including TCI state activation) |
| ZTE | Firstly, we prefer the updated version from Samsung.  Then, regarding use case, we do think mTRP is very important case, and the top issue (maybe tough) should be how to split DL/UL channel/RS resources per TRP, like what we did for CORESET(s) in mDCI-mTRP.  Finally, we share the same views with Apple that maximum value: M=2, N=2 is sufficient. |
| LG | We support M>1 for MTRP and N>1 for MPUE |
| OPPO | Use case: we share similar view as Apple. The only feasible use case is multi-DCI based mTRP. For single-TRP: no use case.  The updated version from Samsung looks better. |
| Qualcomm | Fine with the proposal.  Use case: Both sTRP and mTRP. Do not see why sTRP is not important for reliability enhancement  M=N=2 is fine |
| MediaTek | Share the same view with Apple, ZTE, and OPPO. We see only mTRP is the valid use case. In this case, M =2, N=2 is sufficient. |
| Docomo | Fine with FL proposal or Samsung’s update.  Use case: Both S-TRP and M-TRP. For S-TRP, different TCI states for different subsets of CCs (e.g. inter-band CA). |
| NEC | Support the proposal, and at least multi-TRP is the use case to be supported. |
| Xiaomi | Support the updated version by Samsung. |

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

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### Issue 3 (signaling medium)

Below is the current outcome of the offline discussion.

**Proposal 3.3A**: On Rel-17 unified TCI, for a UE configured with both joint TCI and separate DL/UL TCI, TCI states can be activated via MAC-CE-based TCI state activation for either only joint DL /UL TCI or only separate DL /UL TCI

* When TCI states are activated for joint TCI, the TCI field in DCI formats 1\_1/1\_2 used for beam indication can update only a TCI state associated with joint TCI
* When TCI states are activated for separate DL/UL TCI, the TCI field in DCI formats 1\_1/1\_2 used for beam indication can update only a TCI state associated with either DL-only TCI or UL-only TCI, or update a pair of TCI states associated with DL TCI and UL TCI, respectively
* Detailed MAC-CE-based design is up to RAN2

FFS: the cases of M/N > 1

**Proposal 3.3B:**

On Rel-17 unified TCI framework, for a UE configured with both joint TCI and separate DL/UL TCI, an activated TCI state (via MAC-CE-based TCI state activation) can be a TCI state associated with either joint TCI or separate DL/UL TCI

* Activation of TCI states where at least one activated TCI state is associated with joint TCI and at least another activated TCI state is associated with separate DL /UL TCI is an optional UE capability
* Detailed MAC-CE-based design for the above functionality is up to RAN2
* FFS: the cases of M or N > 1
* FFS: Other related UE capabilities on the number of active QCL and/or UL spatial relation assumptions

Table 3 Additional inputs: issue 3 – switching

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Since technical arguments have been made, please complete the following. If you want to present some new or summarize your arguments, or suggest a compromise, please use the rows below:**  **Proposal 3.3A:**   * **Support: Samsung, LG, OPPO, Qualcomm (1st), MTK (1st), ZTE(1st)** * **Concern: ...**   **Proposal 3.3B:**   * **Support: Apple, Samsung, LG, OPPO, Qualcomm (2nd), MTK, ZTE(2nd), Nokia/NSB** * **Concern: ...**   **If there is no consensus on selecting either proposal 3.3A or 3.3B (or a compromise between the two), the proposed conclusion (RRC configuration) in the chairman notes will be the outcome.** |
| Apple | Support majority view – 3.3B |
| LG | For a sake of progress, we are fine either 3.3A or 3.3B. |
| OPPO | Either A or B is ok to us. |
| Qualcomm | Prefer 3.3A, but can live with 3.3B. For 3.3B, suggest to add the following FFS, e.g. should UE ignore the later separate DL TCI or stick to the earlier joint TCI for UL channels? Because joint TCI must be shared by DL and UL channels based on current definition.  FFS: Whether/how to clarify UE behavior on Tx beam for UL channels when DCI only indicates a separate DL TCI after a joint TCI is indicated. |
| ZTE | We slightly prefer 3.3A that is a complete solution, and we do NOT believe that leaving all aspects to RAN2 is a good solution. |
| Docomo | Either 3.3A or 3.3B is fine for us. |
| Nokia/NSB | We see an edge in 3.3B, despite the fact that it comes with a UE capability, something we do not like but we understand that we need to live with it... |
| NEC | Either 3.3A or 3.3B is fine, and it seems RRC configuration is not prefered by majority companies? We should decide one from 3.3A or 3.3B rather than RRC configuration… |
| Xiaomi | Either 3.3A or 3.3B is fine to us. |

### Issue 4 (MPUE)

**Proposal 4.2**: At least for FR2, support configuring a UE with two SRS resource sets by RRC having different numbers of ports for codebook-based UL transmission

* FFS: Whether SRS resource set is signalled by gNB based on UE reported information
* FFS: Whether to support different SRS ports within a same SRS resource set if more than one SRS resources are configured in the set
* FFS: this can be applied to non-codebook-based UL transmission
* This feature is UE optional

Table 4 Additional inputs: issue 4 – SRS for MPUE

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your input on the above proposal** |
| Apple | We have concern for this proposal.  We think the panel selection should not be in per channel level, otherwise UE may face the situation to activate more panels or simultaneous transmission from multiple panels from multiple CCs. Since unified TCI is applied for multiple channels across CCs, to maintain the same understanding on panel entity based on unified TCI between gNB and UE would be a better way.  The intention for the proposal is to support different number of ports for different panels. Then the two sets should be for two panels, but it seems only 1 panel is valid for transmission based on the indicated TCI. In addition, it may not be necessary to configure 2 sets, but another possible way is to configure 1 SRS resource set and to dynamically update the configuration for the SRS.  With that we suggest the following as a starting point.  **Proposal**   * **Down-select one of the following options to facilitate UL panel selection for CB based PUSCH transmission at least for FR2 in sTRP mode:**   + **Option 1: gNB can configure 2 SRS resource sets for CB with different number of ports**     - **Only 1 resource set is valid to be triggered for SRS transmission and SRI indication for PUSCH**     - **UE does not transmit SRS in the invalid SRS resource set no matter whether it is triggered or not**     - **FFS: How to determine an SRS resource set is valid or invalid**   + **Option 2: gNB can configure only 1 SRS resource set for CB**     - **The number of ports for the SRS resources in the set can be dynamically updated**       * **FFS: signaling details**     - **The number of SRS ports should be aligned with reported UE capability for the corresponding panel entity for SRS/PUSCH** * **The panel entity for the uplink channel is determined based on the RS used to provide spatial relation indication in the indicated unified UL/joint TCI**   + **This applies for PUSCH/PUCCH/SRS**   + **The panel entity for a RS is based on a L1-RSRP report instance**     - **FFS: details** * **Support UE reports maximum number of ports/layers per panel entity** |
| Samsung | Fine with proposal 4.2. Fine with studying FFS highlighted in yellow |
| ZTE | We suggest to remove the highlight FFS bullet that is just to make this issue much more complicated and weaken the motivation, and if so, we are fine with this proposal. |
| LG | We support 4.2. We prefer to use this feature in FR1 as well, but we are ok to make a decision on this later. For the second FFS, either keeping it or deleting it seems to have no critical difference. We are fine either way.  Re Apple’s suggestion, we are fine with adding the last bullet from Apple. But the other option (i.e. Option 2) proposed by Apple seems not aligned with the WID (i.e. ‘fast’ panel selection) and this proposal would allow MAC-CE or DCI overwrites RRC. Since we are running out of time, although we have concerns on Option 2, it is one possibility to list up two alternatives and make a decision in next meeting (it is better than nothing). If we have to go this way, our suggestion is to keep original proposal for Option1. |
| OPPO | We prefer to remove “At lease for FR2” because we also see use case of this for FR1.  Re the highlighted FFS: prefer to remove it to simplify the design.  Re the version suggested by Apple: we are not ok to associate the panel entity here. The spec should not use the word “panel”, right? |
| Qualcomm | Fine with Proposal 4.2. For Apple’s proposal, although we are fine for most points, it may be a bit too late to converge on so many details. It would be more feasible to have 4.2 agreed in general and put detailed aspects in FFS, given the limited remaining time. |
| MediaTek | Suggest the following changes to the proposal 4.2 due to:   * Share the similar view with Apple. Two sets with different ports can be configured to support UE panel configurations with different number of TXRUs. However, since UE only activates one UE panel configuration for UL, only one set is needed for SRS transmission at a time. Regarding the indicated SRI, according to current spec, since it should be associated with the most recent transmission of SRS resource identified by the SRI, it is natural the indicated SRI refers to the valid set. * We also don't see the need of the highlight FFS. Suggest to focus on how to use the two configured sets. * We think the 2nd and 3rd bullets in Apple’s proposal are valid points. However, they may be the next level detail of UE reported information. We prefer to discuss the detail in the next meeting due to running out of the time of this meeting.   **Proposal 4.2**: At least for FR2, support configuring a UE with two SRS resource sets by RRC having different numbers of ports for codebook-based UL transmission   * Only one of the configured SRS resource sets is valid for SRS transmission at a time * FFS: UE reported information, and how gNB signals the valid SRS resource set based on the UE reported information * FFS: this can be applied to non-codebook-based UL transmission * This feature is UE optional |
| Docomo | Support FL’s proposal 4.2 and share similar view with LG/OPPO that this can also be used for FR1. |
| NEC | Support the FL proposal. |

### Issue 5 (MPE)

**Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation, support [one of] the following schemes [(to be down-selected in RAN1#106-e)]:

* Opt1A. Rel.16 P-MPR based (TCI or SSBRI/CRI-specific) together with Virtual PHR (or a modified version)
  + The modified version may be associated with each activated UL TCI or, if applicable, joint TCI, or associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) from candidate pool, if reported.
  + The reporting reuses the event-driven mechanisms from the Rel-16 P-MPR reporting
  + FFS: Definition of virtual PHR and how it is used
* Opt2A. Reporting at least {SSBRI(s)/CRI(s)} (beam/panel level) to indicate gNB beam(s) that are preferred for UL transmission in NW-initiated CSI-report on PUCCH/PUSCH
  + Down-select one option from the followings by RAN1#106-e:
    - Alt1: In a single reporting instance, reporting SSBRI(s)/CRI(s) to indicate gNB beam(s) that is preferred for UL transmission + offsetting L1-RSRP that accounts for MPE effect associated with the SSBRI(s)/CRI(s)
      * FFS: how the offsetting L1-RSRP is calculated with regard to MPE effect
    - Alt2: In a single reporting instance, reporting SSBRI(s)/CRI(s) to indicate gNB beams that is preferred for UL transmission, DL reception (only), or both + L1-RSRP associated with the SSBRI(s)/CRI(s) + virtual PHR or a modified version
      * For each reported SSBRI/CRI, UE determines whether virtual PHR (or a modified version) is reported along with the SSBRI/CRI is reported or not
      * For virtual PHR or a modified version, reuse the same definition in Opt1A
      * FFS: how to inform NW whether a virtual PHR or a modified version is reported or not
    - Alt3: In a single reporting instance, reporting SSBRI(s)/CRI(s) to indicate gNB beams that is preferred for UL transmission, DL reception (only), or both + L1-RSRP associated with the SSBRI(s)/CRI(s) for DL reception
      * FFS: how to inform NW whether a reported SSBRI/CRI is preferred for UL transmission or preferred for DL reception (only)
      * FFS: whether/what to report using bit field for L1-RSRP for UL transmission
* Note:  The determination of power backoff due to power management is the same for Opt2A as for Opt1A

Table 5 Additional inputs: issue 5 – MPE

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| **Company** | **Input** |
| Mod V0 | **Please share your view on the above proposal**  **For proponents of Opt2, please state your preference (Alt1, 2, or 3). I would like to see if it is possible to remove the least supported alternative or, even better, down select**  **Opt2A:**   * **Alt1: Apple, Qualcomm** * **Atl2: Apple, Samsung, ZTE, MTK, Qualcomm** * **Alt3: Samsung, LG** |
| Apple | For Opt2, we are open to Alt1/2.  If acceptable, we would like to suggest a slim version.  **Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation, support [one of] the following schemes [(to be down-selected in RAN1#106-e)]:   * Opt1A. Rel.16 P-MPR based (TCI or SSBRI/CRI-specific) together with Virtual PHR (or a modified version)   + The modified version may be associated with each activated UL TCI or, if applicable, joint TCI, or associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) from candidate pool, if reported.   + The reporting reuses the event-driven mechanisms from the Rel-16 P-MPR reporting   + FFS: Definition of virtual PHR and how it is used * Opt2A. Reporting at least {SSBRI(s)/CRI(s)} (beam/panel level) to indicate gNB beam(s) that are preferred for UL transmission in NW-initiated CSI-report on PUCCH/PUSCH   + FFS: Whether the L1-RSRP is calculated with regard to MPE effect * FFS: Whether/how to support connection for opt1A and opt2A, e.g. Opt1A/Opt2A is triggered/ reported by the same signaling, whether there should be some connections for the reported SSBRI(s)/CRI(s) * Note:  The determination of power backoff due to power management is the same for Opt2A as for Opt1A |
| Samsung | Support proposal. Preference Opt2A. We are fine with Alt2 and Alt3 |
| ZTE | We are fine with the proposal. But, of course, down-selection for three candidates in Opt2A seems better. We support Opt1A and Alt2 in Opt2A. |
| LG | Support the proposal with Alt3 in Opt2A |
| OPPO | We support Opt1A. |
| Qualcomm | Support both Opt1A and 2A, which have different use cases to our understanding. For Opt2A, prefer Alt1 or Alt2 to report detailed UL metric |
| MediaTek | Support both Opt1A and Opt2A. Prefer to remove at least one alternatives from Opt2 (adding rows under Mod’s comment see the temperature). |
| Docomo | First, we would like to clarify our understanding on the second FFS in Alt.3. Is it correctly understanding that L1-RSRP is reported for beams that is preferred for DL reception, and whether/what is reported for beams preferred for UL is FFS, e.g., UL metric similar as in Alt.1 or alt.2 may be reported for beams preferred for UL?  With the above understanding, our first preference is Alt.1 and second preference is Alt.3. Meanwhile we think supporting more than one alternatives can be considered and NW can decide whether to trigger only UL beam reporting (Alt.1) or to trigger both UL and DL beam reporting (Alt.3). For example, when MPE happens, NW can trigger only UL beam reporting if DL beam reporting does not need to be updated. |
| Xiaomi | Thanks for Ericsson more explanation in Round 3. Now I can understand that if all beams in the recent beam report was failed for UL transmission because of MPE, gNB may don’t know which beam can be used for UL transmission. But we think in order to solve the problem in this case, UE can be triggered to report the L1-RSRP for DL reception of preferred beam together with P-MPR or in next beam measurement report. And beam/panel specific P-MPR can be used to indicate preferred beam/panel.    Thus, we think in addition to beam/panel specific P-MPR, it is not necessary to contain “reporting SSBRI(s)/CRI(s) to indicate gNB beam(s) that is preferred for UL transmission” in Option 2A.  And one clarification is that for Alt 2 and Alt 3 in Option 2A, what is the motivation to report the preferred beam for DL reception? |

## Appendix

Issue 1:

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Issue 2:

Proposal 2.1:

* Support/fine: Apple, AT&T, CATT, Ericsson, Intel, [Lenovo/MoM], LG, NTT Docomo, OPPO, [Nokia/NSB], Qualcomm, Samsung, Sony, Spreadtrum, vivo, Xiaomi, ZTE
* Concern: CMCC (postpone), Futurewei (postpone), Huawei/HiSi (no need)

Issue 3:

OptA (original proposal 3.3, chairman notes):

* Support: CATT, CMCC, Ericsson, Fraunhofer IIS/HHI, Fujitsu, Futurewei, Huawei, HiSi, IDC, LG, MTK, NEC, NTT Docomo, OPPO (fine), Qualcomm, Samsung, Spreadtrum, Xiaomi, ZTE

OptB (without UE-capability on mixed activation):

* Support: Apple, Convida, Intel, Lenovo/MoM, Nokia/NSB, Sony

Modified 3.3 – Modified OptB (with UE-capability on mixed activation):

* Support/fine: Convida, Ericsson, Fraunhofer IIS/HHI, Intel, MTK, Nokia/NSB, Qualcomm, Samsung, Sony, Spreadtrum, Xiaomi, ZTE
* Concern: Huawei/HiSi, vivo

**OptA (original proposal 3.3)**

On Rel-17 unified TCI, for a UE configured with both joint TCI and separate DL/UL TCI ~~(including DL-only TCI, UL-only TCI, or DL+UL TCI)~~, TCI states can be activated via MAC-CE-based TCI state activation for either only joint DL /UL TCI or only separate DL /UL TCI

* When TCI states are activated for joint TCI, the TCI field in DCI formats 1\_1/1\_2 used for beam indication can update only a TCI state associated with joint TCI
* When TCI states are activated for separate DL/UL TCI, the TCI field in DCI formats 1\_1/1\_2 used for beam indication can update only a TCI state associated with either DL-only TCI or UL-only TCI, or update a pair of TCI states associated with DL TCI and UL TCI, respectively
* Detailed MAC-CE-based design is up to RAN2
* FFS: the cases of M/N > 1, if supported

Issue 4:

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Issue 5:

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