**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 3

**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)

QCL for CA

*Current status from Round 1 discussion:*

**Proposal 1.3**: On Rel.17 unified TCI framework, for common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs/BWPs, following the Rel-15/16 rules for cross-CC QCL indication

* The source RS determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter for a target CC can be configured in the target CC or other CC
* For intra-band CA, the source RSs determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter for the set of configured CCs are further associated with a same QCL-TypeD RS or a same UL TX spatial relation RS.

**Proposal 1.4**: ‘A single RRC pool of TCI states’ for common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs /BWPs is supported.

* The TCI states can be configured in the PDSCH configuration for each BWP /CC
* The TCI states can be absent in the PDSCH configuration in any BWP /CC, and replaced with a reference to the TCI states in a reference BWP /CC.
* For TCI states configured in a BWP/CC not as a reference BWP/CC
  + As in Rel-15/16, if the CC ID is absent in a TCI state, it applies to the serving cell in which the TCI -State is configured
* For TCI states configured in a reference BWP/CC
  + When the BWP/CC ID for QCL-Type A/D source RS is absent in the TCI state, it implies that the target CC of the TCI state and the corresponding active BWP should be used to determine the source RS
    - Note: In such case, UE uses the corresponding active BWP ID + target CC ID + QCL-Type A/D RS source ID of the TCI state configured in the reference BWP in the reference CC to locate the corresponding QCL Type-A/D source RS
  + When the BWP /CC ID for QCL-Type D source RS is present in the TCI state, it is applied to all corresponding active BWP (s) of target CC(s)
  + Note that cross-CC UL power control indication is FFS as a separate issue
  + FFS: inter-band CA, e.g. two or more sets of configured CCs in a UE
* Introduce UE capability for TCI states configured for each BWP/CC, and UE capability for TCI states configured in a reference BWP/CC and shared by multiple target BWPs/CCs

Table 2 Additional inputs: issue 1 – Qualcomm’s note

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| **Company** | **Input** |
| Mod V0 | **Please share your inputs on proposals 1.3 (used to be 1.3A) and 1.4 (used to be 1.3X)** |
| Qualcomm | For Proposal 1.3, suggest the following change. We still do not see the benefit of mandating such configuration, which cannot ensure real common beam across CCs, since the QCL-D sources per CC can still indicate different Rx beams across CCs even the QCL-D source RSs across CCs share the same QCL-D source. To our understanding, the real common beam across CCs can be achieve by using the same QCL-D source RS across CCs, as in original agreement.   * ~~For intra-band CA,~~ Up to NW’s implementation, the source RSs determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter for the set of configured CCs can be ~~are~~ further associated with a same QCL-TypeD RS or a same UL TX spatial relation RS.   **Agreement**  On Rel-17 unified TCI framework, support common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs:   * The above applies to intra-band CA * The above applies to joint DL/UL and separate DL/UL beam indications * Just as Rel.16, the RS in the TCI state that provides QCL-TypeA [or QCL-TypeB] shall be in the same CC as the target channel or RS * The common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs * […] |
| OPPO | Copied some comments from the email discussion here and questions are added:  Re 1.3A:  it totally reverts the agreement made in 103e meeting. And the newly added wording “following the Rel-15/16 rules for cross-CC QCL indication” also revert the agreement.  What we agreed in 103e meeting is  ‘same/single RS determined ’ for multiple CCs. 1.3A reverts the agreement by the following ways:   * The QCL relationship is defined between A and B. The spec does not specify indirect QCL relationship. Specification in 38.214: “Each *TCI-State* contains parameters for configuring a quasi co-location relationship between one or two downlink reference signals and the DM-RS ports of the PDSCH, the DM-RS port of PDCCH or the CSI-RS port(s) of a CSI-RS resource”. When CSI-RS A is configured as QCL source for PDSCH, the QCL relationship is between DMRS of PDSCH and CSI-RS A. And the spec does not specify that the DMRS of PDSCH Is QCLed with the QCL source of CSI-RS A, i.e., the two-hop indirect QCL relationship is not specified. * The “indirect QCL” in 1.3A does not ensure same beam on multi-CCs: take an example: one CC1: PDSCH is QCLed with CSI-RS A and on CC2, PDSCH is QCLed with CSI-RS B. Both CSI-RS A and CSI-RS B are QCLed with SSB#1. Do the CC1 and CC2 use the same QCL-TypeD? The answer is no. Do the CC1 and CC2 use the same beam? The answer is also  no. * Regarding the newly added “following the Rel-15/16 rules for cross-CC QCL indication”: in rel-16, the cross-CC QCL indication only indicate TCI state ID for the set of CCs and those CCs are still applied with CC-specific TCI state/QCL.     And a couple questions to the proponents: take the following examples:   * In CC#1, the QCL-TypeD RS for PDSCH is CSI-RS #A and In CC#2, the QCL-TypeD RS for PDSCH is CSI-RS #B. And the QCL-TypeD RS for CSI-RS #A is SSB#1 and QCL-TypeRS for CSI-RS #B is SSB#1 too. In this example, which RS is the DMRS of PDSCH in CC#1 is QCLed w.r.t TypeD? And which RS is the DMRS of PDSCH in CC#2 is QCLed w.r.t TypeD? When the UE receives PDSCH in CC#1 and PDSCH in CC#2, can the UE assume a same QCL-TypeD applied on them. * The same question for PDCCH: in this example, CSI-RS #A is configured as the QCL-typeD RS for PDCCH in CC#1 and CSI-RS #B is configured as the QCL-TypeD RS for PDCCH in CC#2. Our question is：when the UE receives PDCCH on both CC#1 and CC#2, can the UE assume they have same QCL-TypeD? * Per our understanding, the answer to the above question is NO according to specification of QCL in 213 and 214.   Re proposal 1.4: Suggest to change the main bullet as follows. We do not need wording “a single RRC pool of TCI states” since the sub-bullets do not talk about that.  **Proposal 1.4**: ~~‘A single RRC pool of TCI states’~~ For common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs /BWPs ~~is supported~~: |
| Apple | Proposal 1.3: We do not agree with QC’s suggestion.  Direct and indirect QCL-TypeD are valid from simultaneous Rx point of view, which is defined in PDCCH+PDCCH QCL-TypeD collision handling rule in 38.213.  We support current proposal 1.3.  Proposal 1.4: We suggest clean-up the proposal as follows.  **Proposal 1.4**: Support the following options for TCI state list configuration in RRC     * Option 1: A TCI state list can be configured in the PDSCH configuration only in the BWP/CC with lowest BWP-ID and CC-ID across CCs in a band   + When the BWP/CC ID for QCL-Type A/D source RS is absent in the TCI state, it implies that the target CC of the TCI state and the corresponding active BWP should be used to determine the source RS     - Note: In such case, UE uses the corresponding active BWP ID + target CC ID + QCL-Type A/D RS source ID of the TCI state configured in the reference BWP in the reference CC to locate the corresponding QCL Type-A/D source RS   + When the BWP /CC ID for QCL-Type D source RS is present in the TCI state, it is applied to all corresponding BWP (s) of target CC(s)   + Note that cross-CC UL power control indication is FFS as a separate issue   + FFS: inter-band CA, e.g. two or more sets of configured CCs in a UE * Option 2: A TCI states list can be configured in the PDSCH configuration for each BWP /CC   + For TCI states configured in a BWP/CC,     - As in Rel-15/16, if the CC ID is absent in a TCI state, it applies to the serving cell in which the TCI -State is configured * Introduce UE capability to report whether UE supports option 1 or option 2 or both |
| MediaTek | P1.3: Regarding the definition of “a set of configured CCs/BWPs”, we prefer to add back the clarification in the early version of this proposal. Regarding the comments from Qualcomm and OPPO, even we have same concern on this proposal doesn't reflect the previous agreement on the single TypeD RS across CCs, we see the use case may be limited if the second bullet of P1.3 is not agreed since only CSI-RS for BM can be used as a cross-CC TypeD RS in current supported QCL rule. We are open to discuss other solutions, but it might be difficult to converge.  **Proposal 1.3**: On Rel.17 unified TCI framework, for common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs/BWPs, following the Rel-15/16 rules for cross-CC QCL indication   * The source RS determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter for a target CC can be configured in the target CC or other CC * For intra-band CA, the source RSs determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter for the set of configured CCs are further associated with a same QCL-TypeD RS or a same UL TX spatial relation RS. * “A set of configured CCs/BWPs” includes all the BWPs in the set of configured CCs in one band     P1.4: For the main bullet, we share similar view with OPPO. For other bullets, we suggest the following changes:   * In Rel-15/16, TCI state pool is configured in the PDSCH configuration per BWP per CC. Thus, detail in the 3rd is not needed. * Regarding the UE capability, we don't see why UE capability is needed for per BWP per CC TCU pool configuration, which is the same in Rel-15/16.   **Proposal 1.4**: ~~‘A single RRC pool of TCI states’~~ For common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs /BWPs ~~is supported~~:.   * An RRC TCI state pool can be configured in the PDSCH configuration (*PDSCH-Config*) for each BWP/CC, as in Rel-15/16. * An RRC TCI state pool can be absent in the PDSCH configuration (*PDSCH-Config*) for each BWP/CC, and replaced with a reference to an RRC TCI state pool in a reference BWP/CC.   + Introduce UE capability for this operation * For an RRC TCI state pool configured in a reference BWP/CC:   + When the BWP/CC ID for QCL-Type A/D source RS is absent in the TCI state, it implies that the target CC of the TCI state and the corresponding active BWP should be used to determine the source RS     - Note: In such case, UE uses the corresponding active BWP ID + target CC ID + QCL-Type A/D RS source ID of the TCI state configured in the reference BWP in the reference CC to locate the corresponding QCL Type-A/D source RS   + When the BWP/CC ID for QCL-Type D source RS is present in the TCI state, it is applied to all corresponding active BWP (s) of target CC(s)   + Note that cross-CC UL power control indication is FFS as a separate issue   + FFS: inter-band CA, e.g. two or more sets of configured CCs in a UE |
| ZTE | Proposal 1.3, we support the QC’s proposal, quite like that we have a requirement guaranteeing by NW as in Rel-16. But, for progress, we can live with previous version.  Proposal 1.4, we are fine the OPPO’s update. If going with Apple’s updated version, we wonder why we need a rule of ‘only in the BWP/CC with lowest BWP-ID and CC-ID across CCs in a band’. We prefer to have an explicit configuration for this case, e.g., introducing a reference CC ID and reference BWP ID parameter per BWP per CC. Then, compared with ‘option’, using ‘mode-1/2’ seems to be better considering we do not want to do any down-selection herein. |
| Docomo | We support the proposal 1.3A.  We actually prefer Qualcomm’s suggestion, but we are also fine with the current proposal. In Rel.15/16, it was up to gNB implementation whether CC-specific QCL-Type D RSs on different CCs are further associated to the same RS (e.g. SSB). However, it is “de facto” mandatory for gNB to configure the further association in CA, to let UE know the CC-specific QCL-Type D RSs on different CCs are the same QCL-Type D assumption. Thus, we don’t see much difference whether to adapt Qualcomm’s update or not, in practical operation.  Re OPPO’s comment:  As we commented multiple times, Proposal 1.3A says “*The determined CC-specific source RSs for the set of configured CCs/BWPs are further associated with a same QCL-TypeD RS*.”  Thus, it does not contradict with the previous agreement.  Re OPPO’s question:  In your example: when CSI-RS#A on CC1 is QCL-Type D RS of PDSCH/PDCCH DMRS and CSI-RS#B on CC2 is QCL-Type D RS of PDSCH/PDCCH DMRS, and both CSI-RS#A and CSI-RS#B are QCLed with the same SSB,   * Same as Rel.15, UE can receive PDSCHs/PDCCHs on CC1 and CC2 simultaneously, because PDSCHs/PDCCHs are assumed as the same QCL-Type D (indirectly). * This is typical Rel.15 gNB operation for CC-specific QCL type D configuration (QCL-Type A TRS + QCL-Type D TRS) to enable CA. * Please note that CC-specific QCL type D configuration are already supported and widely used in Rel.15, and it already supports CA operation. * Proposal 1.3A just reuses Rel.15/16 QCL rules.   Proposal 1.4: We are fine either of Apple’s update or MediaTek’s update. For MediaTek’s update, we’d like to update as “RRC-configured TCI state pool” or “~~RRC~~ TCI state pool”, to clarify that we don’t intend to introduce new terminology. |
| LG | Fine with the current version of FL proposal 1.3 and we have a same understanding on the QCL rule of the proposal 1.3 with Docomo. |
| Ericsson | Proposal 1.3: Support. We think this is a good clarification of the earlier agreement, and it is how we interpreted that agreement: this is mandating a certain NW configuration which is typically not done in RAN1, but we were OK with that restriction already when the agreement was made, and we are still OK with it. We do not understand what “true common beam” in Qualcomm’s response means – could you clarify?  Proposal 1.4: We support Oppo’s proposal to remove ‘A single RRC pool of TCI states’.  Our thinking was that any CC where the PDSCH configuration includes TCI states would be a reference CC that could be referred to by another CC. We do not see that the addition in red in the original proposal is necessary: can someone explain? We also see this as a compromise between the ‘per CC’ and ‘across CC’ configuration options, since it provides a soft transition between the two.  We do not understand Apple’s proposal, where did the two options come from?  We would understand the need for a UE capability on the total number of configured TCI states across all CCs, where only the TCI states in reference CCs/BWPs would be counted. |

The need for Notes proposed by Qualcomm

The following note (highlighted in yellow) was proposed by Qualcomm to be added at the end of the agreement to clarify the feasibility of a particular use case:

**Agreement**:

On Rel.17 unified TCI framework, for any DL RS that does not share the same indicated Rel-17 TCI state(s) as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC, but can be configured as a target DL RS of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool), discuss and down-select by RAN1#106-e (August 2021) between the following two alternatives:

* Alt1. Rel-15/16 TCI state update signaling/configuration mechanism(s) are reused to update/configure the Rel-17 TCI state
* Alt2. Rel-17 TCI state update signaling/configuration mechanism(s) are used, e.g. with Rel-17 MAC-CE/DCI-based beam indication for Rel-17 joint/separate TCI

Note: The DL RS includes CSI-RS and DMRS for PDSCH or PDCCH

Note: For some channels/signals, only one of the above two alternatives may apply (to be discussed).

Note: The selected alternative can be used by NW implementation to align the Rel-17 DL TCI state between two target channels/signals

* E.g. TCI state #1 can be activated for PDCCH+PDSCH as in Rel-17 and can also be simultaneously configured for a CSI-RS resource for BM as in Rel-15/16.

Table 2 Additional inputs: issue 1 – Qualcomm’s note

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| **Company** | **Input** |
| Mod V0 | **Please share your input whether the Note is needed or not, or proposed rewording** |
| OPPO | (From ROUND 1) In our view, it is not needed because none of proposal 1.4/1.5/1.6 propose to restrict TCI states that can be configured to a channel or reference signal.  Any TCI state in the configured pool can be configured to a channel or CSI-RS as long as the QCL contained in that TCI state satisfies the QCL configuration types specified for each channel or CSI-RS resource. The wording in the Note might even cause some confusion, for example a TCI state with TypeA and TypeD activated for PDCCH+PDSCH cannot be configured for CSI-RS for tracking because the QCL type does not match. |
| Qualcomm | We are fine without any note if no company has different view. The note is because the understanding may be different based on some offline discussion with other companies. |
| Apple | Either to keep or remove the note is fine to us. |
| MediaTek | It is clear w/o the note. |
| ZTE | Either to keep or remove the note is fine to us. |
| Xiaomi | Either to keep or remove the note is fine to us. |
| Docomo | Either to keep or remove the note is fine to us. |
| Ericsson | Either to keep or remove the note is fine to us. |

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

*Current status from Round 1 discussion:*

**Proposal 2.1**: On Rel.17 beam indication enhancements for L1/L2-centric inter-cell mobility, support the following:

* At least for UE reception (on PDSCH and PDCCH) and transmission (on PUSCH and PUCCH) associated with UE-dedicated CORESETs, Rel-17 MAC-CE-based and DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation)
  + FFS: Whether the above is supported only for joint TCI, or both joint TCI and separate DL/UL TCI (including that, if separate DL/UL TCI is supported, the DL TCI and UL TCI associated with a same cell)
  + FFS: Whether to support activation of TCI states for more than one cells simultaneously
* The DL QCL and UL spatial relation rules already agreed for intra-cell scenario
* The use of SSB associated with a physical cell ID different from that of the serving cell as an indirect QCL reference for UE-dedicated PDCCH/PDSCH
  + Note: When RS X is an indirect QCL reference of a target channel, there exists at least one other source signal on the QCL chain between RS X and the target channel
  + FFS (to be decided in RAN1#106-e): Whether SSB associated with a physical cell ID different from that of the serving cell can also be used as a direct QCL reference (source RS) for UE-dedicated PDCCH/PDSCH
* Note: It is assumed that serving cell and/or RNTI(s) are not mandated to change when L1/L2-centric inter-cell mobility is configured and utilized

**Proposal 2.2**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP, decide by RAN1#106-e whether to support the following RS types as measurement RS or not:

* CSI-RS for mobility/RRM associated with a non-serving cell
* CSI-RS for BM configured for or QCLed with a non-serving cell SSB
* CSI-RS for tracking configured for or QCLed with a non-serving cell SSB

Note: If another beam metric other than L1-RSRP is supported (e.g. L3-RSRP is still FFS), the above also applies

Table 3 Additional inputs: issue 2

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your input on the above proposals** |
| Qualcomm | For Proposal 2.2, we suggest the same change for CSI-RS for mobility/RRM, since “associated with” may have different interpretations. Also, we are fine to put CSI-RS for BM as FFS, since CSI-RS for BM might be beneficial to identify P2 beams within the non-serving SSB to our understanding.  CSI-RS for mobility/RRM ~~associated with~~ configured for or QCLed with a non-serving cell |
| Apple | For proposal 2.1, we suggest we remove the note or change it as follows  “FFS: additional impact if serving cell and/or RNTI change is supported”  For proposal 2.2, support. |
| ZTE | Regarding proposal 2.1, as we mentioned many time before, ‘the assumption about the change of serving cell/RNTI or not’ are not necessary. If required, we can further study this issue after receiving RAN2-LS. We are fine with other bullets.  Regarding proposal 2.2, ‘configured for’ a non-serving cell SSB is confusing. Does it mean that …. Configured for non-serving cell or QCLed with a non-serving cell SSB? |
| Xiaomi | As for proposal 2.2, we want to clarify the difference of “ …for L1/L2-centric inter-cell mobility” and “…for inter-cell mTRP” in the main bullet. In my understanding, “ …for L1/L2-centric inter-cell mobility” means the measurement/reporting is used for select a non-serving cell, while “…for inter-cell mTRP” means the non-serving cell has been configured as one TRP to the UE for transmission/reception. If my understanding is right, can we move “ and inter-cell mTRP” in the main bullet or provide two proposals for these two scenarios separately. Since we think CSI-RS for BM configured for or QCLed with a non-serving cell SSB can be supported for P2 beam management of the non-serving cell.  If my understanding is wrong, please feel free to let me know, thanks! |
| Docomo | Support the proposals. |
| CMCC | For proposal 2.2, we think “configured for a non-serving cell” is not clear to us. What is the difference between “configured for a non-serving cell” and “QCLed with a non-serving cell SSB”? If they are the same, we can just keep one of them. |
| LG | On Proposal 2.1, we have a similar view with ZTE related to the change of SC/RNTI that it is reasonable to further discuss depending on the result of RAN2 LS.  On Proposal 2.2: Support |
| Ericsson | Proposal 2.1: Support, with the following modification:  In RAN2 we have the following agreement:   * RAN2 confirm the simplified procedures on the L1L2 mobility model as a baseline RAN2 understanding:   Scenario 2: L1L2 mobility model (i.e. with serving cell change)  1. UE receives from serving cell, configuration of SSBs of the cell with different PCI for beam measurement/ serving cell change.  2. UE performs beam measurement for the cell with different PCI and report it to serving cell.  3. Serving cell configuration for cell with other PCI is provided to the UE by RRC (pre-configuration for serving cell change, FFS if this step is same as 1).  4. Based on the above reports, TCI states for cell with different PCI is activated along with the serving cell change (by L1/L2 signaling). FFS if this is multiple steps.  5. UE changes the serving cell and starts receiving/transmitting using the pre-configured UE-dedicated channel and TCI states.  So RAN2 has agreed to facilitate serving cell change. The note is thus irrelevant. However, the case without update on RNTI is possible:   * R2 didn’t see a problem with using different C-RNTIs for different cells. Different C-RNTI seems more natural in a mobility scenario. No conclusion in R2 for mTRP scenario. * RRC configurations of the cells for L1/L2 centric mobility, including C-RNTI, are configured by RRC.   So the C-RNTI in the different cells is up to NW configuration.  Therefore, we propose to modify the note:   * Note: It is assumed that RNTI(s) are not mandated to change when L1/L2-centric inter-cell mobility is configured and utilized   Proposal 2.2: Support |

### Issue 3 (signaling medium)

### Issue 4 (MPUE)

### Issue 5 (MPE)