**3GPP TSG RAN WG1 #107-e R1-2111715**

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

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

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

**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  **Concern**: OPPO, ZTE, Lenovo/MotM |
| 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 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 * All the Rel-17 UL or, if applicable, joint TCI states configured to SRS resources in the same set should be 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  **Concern**: [OPPO], ZTE, Lenovo/MotM |
| 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  **FL Note**: Discussed offline [1] | **Support/fine**: Nokia/NSB, Ericsson, Samsung, Apple, MTK, Fraunhofer IIS/HHI, CMCC, Futurewei, Intel, vivo, NEC, AT&T, QC  **Concern**: Sony, OPPO, Lenovo/MotM, NTT Docomo |
| 1.4 | **Proposal 1.B**: On Rel.17 unified TCI framework, for Rel-17 unified TCI, when a UE is configured with separate DL/UL TCI, the largest number of configured TCI states for DL TCI state update is 128 per BWP per CC, and the largest number of configured TCI states for UL TCI state update is 64 per BWP per CC   * The number of configured TCI states a UE can support is a UE capability (possible values TBD in UE feature session) * Note: This doesn’t imply that UL TCI shares the same TCI state pool as or uses a different TCI state pool from joint DL/UL TCI   **FL Note**: Already discussed last meeting at length | **Support/fine**: NTT Docomo, Apple, Samsung, ZTE, [Nokia/NSB], Futurewei, [LG], Xiaomi, Fraunhofer IIS/HHI, Sony, Huawei, HiSilicon, Spreadtrum, MTK, Ericsson, AT&T, CMCC, TCL  **Concern**: QC |
| 1.5 | **Proposal 1.C.1**: On Rel-17 unified TCI framework, after X symbols from the UE receives the BFRR from NW, the UE assumes the same QCL parameter as the ones associated with the index qnew for all UE-dedicated PDSCH/PDCCH receptions in a CC or in a set of configured CCs with common TCI state ID activation and update, as well as other signals/channels configured to sharing the same indicated Rel-17 TCI state as UE-dedicated PDSCH/PDCCH reception.   * Above applies to both Rel-15 SpCell BFR and Rel-16 SCell BFR   **FL Note**: Discussed offline [1], MTK’s version only for DL | **Support/fine**: QC  **Concern**: |
| 1.6 | **Proposal 1.C.2**: On Rel-17 unified TCI framework, if the UE is configured with joint DL/UL TCI mode, after X symbols from the UE receives the BFRR from NW, the UE uses the same UL spatial filter as the one associated with the index qnew for all dynamic-grant/configured-grant based PUSCH transmissions and all of dedicated PUCCH resources in a CC or in a set of configured CCs with common TCI state ID activation and update, as well as other signals/channels configured to sharing the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources.   * Above applies to both Rel-15 SpCell BFR and Rel-16 SCell BFR * FFS: UL PC control including qu, qd, and closed loop index   **FL Note**: Discussed offline [1], MTK’s version only for UL | **Support/fine**: QC  **Concern**: |
| 1.7 | **Proposal 1.D**: On Rel-17 unified TCI framework, for [CSI-RS without QCL configuration (e.g. P/SP-CSI-RS except for P-CSI-RS for BM, BFD-RS)], the UE assumes that its QCL is based on the indicated Rel-17 TCI state as UE-dedicated PDSCH/PDCCH  **FL Note**: Need to discuss and clarify what ‘CSI-RS without QCL configuration’ entails (I tend to agree it is ambiguous as many pointed out – I added some examples but I don’t think it resolves the lack of clarity) | **Support/fine**: Nokia/NSB, Ericsson, Apple  **Concern**: Sony, OPPO, Samsung, ZTE, MTK, Lenovo/MotM, CMCC, QC |
| 1.8 | **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)**: Convida, Huawei/HiSi, Ericsson, ZTE, CMCC, Samsung, Sony, Nokia/NSB, Qualcomm, Fraunhofer IIS/HHI, Futurewei, MTK, NTT Docomo, AT&T, Lenovo/MotM, Intel, Xiaomi, CATT, TCL  **Concern**: Apple, OPPO |
| 1.9 | **Proposal 1.F**: On Rel.17 unified TCI framework, after initial access or reconfiguration with sync, the UE assumes a TCI state based on the SSB identified during random access for DL reception and UL transmission until the UE receives beam indication and is indicated a TCI state for the UE-dedicated PDCCH/PDSCH in a CC and, respectively, dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources in a CC.  **FL Note**: TCI state assumption between initial access and the first instance of beam indication. This version is a revision of Samsung’s proposal (removing unnecessary/obvious parts) | **Support/fine:**  **Concern: QC** |
| 1.10 | **Proposal 1.G**: On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, when both PL-RS and spatial relation RS in the UL or (if applicable) joint TCI state are not the same [and they are not CSI-RS for BM with repetition ‘ON’], “beam alignment” also pertains to the following events:   * The PL-RS is identical to the QCL Type-D source RS or UL spatial relation RS of the spatial relation RS in the UL or (if applicable) joint TCI state * The QCL Type-D source RS of PL-RS is identical to the spatial relation RS in the UL or (if applicable) joint TCI state * The QCL Type-D source RS of PL-RS is identical to the QCL Type-D source RS or UL spatial relation RS of the spatial relation RS in the UL or (if applicable) joint TCI state   **FL Note:** Any additional event (bullet) doesn’t seem acceptable for a number of companies. Even the above, some still have concern | **Support/fine:** Apple, MTK, Convida, Lenovo/MotM, Qualcomm, Samsung, NTT Docomo, CMCC, Nokia/NSB, Futurewei, CATT, Intel (without last bullet from prev), Fraunhofer IIS/HHI, Spreadtrum, TCL  **Concern:** ZTE, vivo, OPPO (4th case not included), Ericsson (use case unclear), LG (5th case not included) |

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** |
| Qualcomm | For 1.A.1, support  For 1.A.2, support  For 1.A.3, support  For 1.B, do not support, no need 128 DL TCI to optimize separate DL/UL TCI performance, unless 64 DL TCI and 32 for UL TCI are canadiate values for UE capability  For 1.C.1, support  For 1.C.2, support  For 1.D, do not support. Withoout QCL means this RS serves as root QCL source like SSB in current spec  For 1.E, support  For 1.F, do not support. This requires the TCI must have SSB as root QCL source RS. We think legacy rule is sufficient, i.e. CORESET follows selected SSB beam, while PUCCH follows Msg3 Tx beam.  For 1.G, support |
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### Issue 2 (inter-cell beam management)

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.1 | **Proposal 2.A**: On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP, Rel-15 L1-RSRP reporting format is reused for all SSBRI-RSRP pairs in one L1-RSRP reporting instance, i.e. for K>1, (K-1) 4-bit differential L1-RSRP(s) calculated relative to the reference (absolute) 7-bit L1-RSRP  **FL Note: This was discussed in the last meeting at length and during offline [1]** | **Support/fine**: Apple, OPPO, MTK, NTT Docomo, Samsung, LG, Spreadtrum, Qualcomm, Sony, Xiaomi, Nokia/NSB, CATT, Huawei/HiSi, Lenovo/MotM, ZTE  **Concern**: |
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| 2.2 | **Conclusion 2.B:** On Rel-17 enhancements for inter-cell beam management, on QCL assumption for paging and short message reception after being activated with at least one TCI state associated with PCI different from serving cell, in Rel-17, there is no consensus on requiring the UE to monitor paging and short message associated with the newly indicated TCI state associated with a PCI different from the serving cell.  **FL Note: This was discussed in the last meeting at length and during offline [1]**  On Rel-17 enhancements for inter-cell beam management, on QCL assumption for paging and short message reception after being activated with [only one] TCI state[(s)] associated with PCI different from serving cell:   * Alt0. The UE is not required to monitor paging and short message associated with the newly indicated TCI state associated with a PCI different from the serving cell * Alt1. The UE is to monitor paging and short message in USS configured for paging and short message with the newly indicated TCI state associated with a PCI different from the serving cell * Alt2. The UE is to monitor paging and short message in Type2 PDCCH CSS configured for paging and short message with the newly indicated TCI state associated with a PCI different from the serving cell   **Alt0 (default – without any agreement this is the outcome).**   * Support: OPPO, vivo, Lenovo/MotM, MTK (2nd), CATT, NTT Docomo, Intel, NEC, Qualcomm * Concern: Huawei, HiSilicon, Apple   **Alt1**.   * Support: Huawei/HiSi (2nd), Ericsson (>=1), Samsung (2nd preference), Spreadtrum, AT&T, Nokia/NSB * Concern: MTK, OPPO, NTT Docomo, ZTE, Qualcomm   **Alt2**.   * **Support/fine:** Huawei/HiSi, Apple, ZTE (>=1), Samsung (>=1), Futurewei, Spreadtrum, AT&T, Sony (>=1), MTK, Xiaomi, CMCC, Nokia/NSB, * **Concern:** vivo, Lenovo/MotM, LG, Intel, Qualcomm, OPPO | |
| 2.3 | **Conclusion 2.C:** On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP, in Rel-17, there is no consensus on supporting event-driven beam reporting  **FL Note**: The latest proposal below from last meeting was discussed at length and concerns still remained  **Proposal [2.E]**: On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP, support event-driven beam reporting   * If UE consecutively identify an event happens, UE can trigger the L1-RSRP report * The event at least includes:   + The L1-RSRP from one SSB within list of SSBs with PCIs different from serving cell is larger than the best L1-RSRP measured from a list of serving cell SSB plus an offset, where the offset is configured by RRC   + The L1-RSRP from one SSB within list of SSBs with PCIs different from serving cell is larger than a pre-defined value which is configured by RRC   + The list of serving cell SSBs and SSBs with PCIs different from serving cell are configured by RRC   + Indication for activating a reporting configuration * The L1-RSRP report is transmitted by MAC CE, which includes   + SSBRI from the list of SSBs with PCI different from serving cell   + L1-RSRP for the corresponding SSB * A prohibit timer is introduced to prohibit UE sends multiple L1-RSRP report MAC CEs, which is similar to PHR   **Support/fine**: Apple, NTT Docomo, ZTE, Nokia/NSB, Qualcomm, AT&T, Xiaomi, Sony, Huawei, HiSilicon, CATT  **Concern**: Futurewei, Intel, LG (concern on MAC CE), MTK, Ericsson, Samsung (concern on MAC CE), OPPO, vivo, Spreadtrum, Lenovo/MotM (remove last bullet) | |

Table 4 Additional inputs: issue 2

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| **Company** | **Input** |
| Mod V0 | 1. **Check and update your view in Table 3** 2. **Share more inputs here if needed** |
| Qualcomm | For 2.A, support  For 2.B, no need for such conclusion. The agreement is already clear, i.e. only UE dedicated PDCCH/PDSCH can be on non-serving PCI. Given this agreement, UE will not receive paging/short message on non-serivng PCI. The agreement also says if gNB wants UE to receive paging, MAC-CE will be used to switch UE back to serving cell. So the issue is already addressed without ambiguity.  For 2.C, fine |
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### Issue 3 (signaling medium)

Table 5 Summary: issue 3

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| **#** | **Issue** | **Companies’ views** |
| 3.1 | The number of BAT values a UE can be configured with (per CC/BWP):   * Alt1. One * Alt2. Two for MPUE   + BAT1 for beam switching within the same panel   + BAT2 for beam switching across different panels where both panels are activated | **Alt1**: Ericcson, OPPO, QC  **Alt2**: Samsung |
| 3.2 | Further enhancements on ACK/NAK for DCI formats 1\_1/1\_2 with DL assignment when used for beam indication | **DCI ACK/NAK:** CATT, Apple, Xiaomi, Samsung, Intel (with higher priority for beam indication DCI ACK/NACK), ASUSTek  **DL assignment ACK/NAK, but only ACK can be used to confirm beam indication:** NEC, OPPO, NTT Docomo (already agreed), Huawei. HiSilicon, Xiaomi, QC |
| 3.3 | Support for additional beam indication scheme for Rel-17 unified TCI framework beyond agreement to-date | **No additional beam indication scheme is supported:** CATT, Samsung, Ericsson, Spreadtrum, CMCC  **DCI formats 0\_1/0\_2 with UL grant (for UL-only TCI of separate DL/UL TCI)**: IDC, LG, Sony, MTK, Intel, Xiaomi, TCL, Qualcomm, NEC  **New dedicated DCI format for beam indication**:  **Group-common DCI**: Sony, Intel, MTK, NTT Docomo, Qualcomm  **When more than one TCI codepoints are activated by MAC CE, the activated TCI state(s) for the lowest codepoint is/are applied**: Huawei/HiSi, vivo (until DCI is indicated), Convida (after MAC CE activation), MTK (until DCI is indicated, only for the case if the currently applied TCI state is not one of the activated TCI states), NTT Docomo, NEC |
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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 | For 3.1, support Alt1  For 3.2, reusing PDSCH ACK is sufficient. If NACK, gNB can just retransmit for the worst case. Scheduled PDSCH BLER should be controlled to be low anyway  For 3.3, support UL grant also indicating unified TCI, and group common DCI to reduce DCI overhead |
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### Issue 4 (MP-UE)

Table 7 Summary: issue 4

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| **#** | **Issue** | **Companies’ views** |
| 4.1 | **Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection,   * Support the UE reporting a list of UE capability value sets   + Each UE capability value set comprises at least the max supported number of SRS ports   + [No two value sets can have identical entries]   + FFS: which type(s) of UE capability other than the max supported number of SRS ports is included in a UE capability value set and whether the UE capability value set can be common across all BWPs/CCs in same band or BC are discussed under UE feature agenda item * The correspondence between a CSI-RS and/or SSB resource index and one of the UE capability value sets in the reported list is determined by the UE (analogous to Rel-15/16) and is informed to NW in a beam reporting instance.   + The Rel-15/16 beam reporting is reused, i.e. the index of corresponding UE capability value set is reported along with the pair of SSBRI/CRI and L1-RSRP/SINR (up to 4 pairs, with 7-bit absolute and 4-bit differential) in the beam reporting UCI * Support multiple codebook-based SRS resource sets with different number of SRS ports   + ~~The indicated SRI is based on the SRS resources corresponding to a selected SRS resource set [which need to be aligned with the UE capability based on the informed correspondence]~~   + FFS: Decide in RAN1#107e, whether the SRS resource set is selected by the UE or NW   **FL Note: Discussed offline at length [1]. I removed the sub-bullet of 3rd bullet since it is not proper to define NW behavior. Added red text in brackets to address Ericsson’s concern** | **Support**: InterDigital, ZTE, Sony, Xiaomi, Lenovo/MotM, Fraunhofer IIS/HHI, Nokia/NSB, AT&T, Samsung, MediaTek, QC  **Concern**: OPPO, Ericsson (need to add red text in 1st bullet), Intel (1st and 3rd bullets), Apple |

Table 8 Additional inputs: issue 4

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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 | For 4.A, support and also fine for the red text in 1st bullet |
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### Issue 5 (MPE)

Table 9 Summary: issue 5

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| **#** | **Issue** | **Companies’ views** |
| 5.1 | On Rel.17 enhancements to facilitate MPE mitigation, the selection of N from a candidate SSB/CSI-RS resource pool:   * Alt1. Based on L1-RSRP minus P-MPR value for each resource * Alt2. No RAN1 spec impact (possibly left to RAN4) | Alt1:   * **Support**: MTK, Ericsson, Samsung, LG, Qualcomm, Spreadtrum, Xiaomi, IDC, Sony * **Concern**: vivo, OPPO, Apple   Alt2:   * **Support**: vivo, Intel, OPPO, Apple * **Concern**: |
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Table 10 Additional inputs: issue 5

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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 | Support Alt1 to have aligned understanding between gNB and 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) |