**3GPP TSG RAN WG1 #106bis-e R1-2110514**

**e-Meeting, October 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**: On Rel.17 unified TCI framework, for Rel-17 unified TCI, the largest number of configured TCI states is given as follows (following Rel-15/16 principles):   * When a UE is configured with joint DL/UL TCI: the largest number of configured TCI states for joint DL/UL TCI state update is 128 per BWP per CC * Further discuss and decide between the following when a UE is configured with separate DL/UL TCI:   + Alt1. 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   + Alt2. The total largest number of configured TCI states for DL TCI and UL TCI state update is [128/192] per BWP per CC]   Note: TCI state pool for separate DL/UL TCI indication is still FFS  **FL Note: Need to decide between Alt1 and Alt2 in this meeting** | **Alt1**: NTT Docomo  **Alt2**: NTT Docomo |
| 1.2 | **Proposal 1.B.1:** 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 | **Support/fine**: Convida, Huawei/HiSi, Ericsson, ZTE, CMCC, Samsung, Sony, Nokia/NSB, Qualcomm, Fraunhofer IIS/HHI, Futurewei, MTK, NTT Docomo...  **Concern**: Apple, OPPO, |
| 1.3 | **Proposed conclusion 1.I**: On Rel.17 unified TCI framework, there is no consensus in supporting the following DL source RS type:   * SSB as QCL Type-D source RS, with TRS as QCL Type-A source RS * SRS for BM as QCL Type-D source RS, optionally with TRS as QCL Type-A source RS     **FL Note: This has been the situation (for at least 5 meetings) on additional source RS type for DL QCL Type-D reference for DL common UE-dedicated reception on PDSCH and all/subset of CORESETs:**  **SSB, with TRS as QCL Type-A source RS**   * **Yes (5): ZTE, Samsung, MTK, vivo, Qualcomm** * **No (10): Spreadtrum, OPPO, Intel, Apple, Sony, Ericsson, Huawei/HiSi, Futurewei, Docomo** * **Yes (10): ZTE, IDC, Spreadtrum, Samsung, Convida, Nokia/NSB, vivo, Xiaomi, Sony** * **No (11): OPPO, Fraunhofer IIS/HHI, MTK, Intel, Ericsson, Huawei/HiSi, LG, Futurewei, Docomo** | **Support/fine**: NTT Docomo  **Concern**: |
| 1.4 | **Proposal 1.B.2:** On Rel.17 unified TCI framework, for Rel-17 unified TCI,   * If there is at least one DL channel/signal that does not share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH/PDCCH (via Rel-17 MAC-CE/DCI TCI state update), it is signaled via RRC. * If there is at least one UL channel/signal that does not share the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all of dedicated PUCCH resources (via Rel-17 MAC-CE/DCI TCI state update), it is signaled via RRC.   FFS: Whether this configuration is per resource, per resource set, or per CORESET  **FL Note: Re the wording concern from Futurewei and ZTE (which shares vs which doesn’t share), this seems immaterial as long as the respective RRC parameters employ correct range of values. That is, this should be up to RAN2. Please reconsider.** | **Support/fine**: Convida, Ericsson, [Huawei/HiSi], CMCC, Samsung, Sony, NTT Docomo, Lenovo/MotM, ZTE, Intel, Nokia/NSB, Qualcomm, LG, MTK,  **Concern**: Apple, OPPO, [Futurewei, ZTE] (wording issue) |
| 1.5 | **Proposal 1.H**: On Rel.17 unified TCI framework, for the case when the setting of (P0, alpha, closed loop index) for PUSCH, PUCCH, and/or SRS are associated with UL or (if applicable) joint TCI state per BWP:   * [Support the following: for each of the PUSCH, PUCCH, and/or SRS, one setting is optionally associated with each of the UL or (if applicable) joint TCI state in a BWP via RRC] Alt1   VS   * [Support the following: for each of PUSCH, PUCCH, and/or SRS, each of UL or (if applicable) joint TCI state is optionally associated with one of configured settings in a BWP via MAC-CE.] Alt2   **FL Note: RAN2 cannot decide for RAN1 whether the setting is configured via RRC or can be updated via MAC CE. Whether the additional flexibility from MAC CE is truly beneficial or not is not within RAN2 capability to assess.**  **Thus, if there is no consensus on this issue, the previous agreement on optionally associating UL PCP setting (other than PLRS) with UL or, if applicable, joint TCI state shall be reverted, i.e. the setting is not associated with UL or, if applicable, joint TCI state – simply because such association is an incomplete feature** | **Alt1**:   * **Support/fine**: Ericsson, vivo, Qualcomm, Intel, NTT Docomo * **Concern**:   **Alt2**:   * **Support/fine**: ZTE, Samsung, Futurewei, MTK, * **Concern**: |
| 1.6 | For separate DL/UL TCI, UL TCI state pool  Alt1: Shared pool with joint/DL TCI state  Alt2: Separate pool  **FL Note: Strictly speaking, this could be decided in RAN2. Therefore, if there is no consensus, this will be left to RAN2** | **Alt1:**   * **Support/fine (12)**: vivo, Spreadtrum, Samsung, Xiaomi, ZTE, Qualcomm, MTK, Convida, NTT Docomo, Intel, CATT, TCL * **Concern**:   **Alt2**:   * **Support/fine (11)**: CMCC, Ericsson, Futurewei, Huawei/HiSi, Fraunhofer IIS/HHI, IDC, Sony, Apple, AT&T * **Concern**: |
| 1.7 | **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 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 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,  **Concern:** ZTE, vivo, Spreadtrum, Intel, |
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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 Note: BFR for unified TCI will be a main topic in the next meeting. Please prepare your Tdocs accordingly for RAN1#107-e** |
| NTT Docomo | Our view are added in the table.  **Proposal 1.A**: We support either Alt.1/2. For UL, we always assume beam correspondence, and we configure one DL resource out of 64 SSB beams as UL spatial relation. Hence, at least 64 RRC-configured UL TCI states are necessary per BWP.  **Proposal 1.B.1:** Since Rel.15/16 spec. support this QCL chain, we think it is fair to support it for Rel.17 unified TCI, because some operators may already use this QCL chain. We assume it will be hard to change QCL chain for operators, who already deployed in their Rel.15/16 NW.  **Conclusion 1.I**: Considering the limited remaining RAN1 meetings, we think we should accept the conclusion.  **Proposal 1.B.2:** Support.  **Proposal 1.H**: Support Alt.1. The setting of (P0, alpha, closed loop index) is already associated with each of TCI states. We don’t see the use case to update the setting by MAC CE additionally.  **Proposal 1.G**: Support. |
| vivo | **Proposal 1.A**: Support Alt2 when a UE is configured with separate DL/UL TCI including up to 128 TCI states.  We think it is not necessary to distinguish between the largest number of configured separate DL DCI states and the largest number of configured separate UL DCI states. DL TCI state and UL TCI state can be activated and indicated based on network implementation from a R17 TCI pool including up to 128 configured TCI states.  **Proposal 1.B.2:**  Fine with Proposal 1.B.2.  **Proposal 1.H**: Support Alt1.  For Alt2, we don’t see why the UL PC settings need to be dynamically associated with TCI state by MAC CE. This is against the spirit we have when the compromise is made in RAN1 #105e meeting to minimize RAN1 effort. For Rel-17 UL PC parameter setting, gNB can configure the association between multiple settings and the UL or (if applicable) joint TCI state by RRC for each of the PUSCH and PUCCH and SRS.  **For issue 1.6**, support Alt1.  TCI state from a TCI state pool is indicated as joint TCI state or separate DL and/or UL TCI state can be configured separately.  **Proposal 1.G**: Don’t support this proposal.  We still believe this is overdesign especially considering there is no RAN1 specifcation impact for this. RAN4 could find out their own way for dealing with this. |
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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.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 non-serving cell SSBs 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 list of serving cell SSBs and non-serving cell SSBs are configured by RRC * The L1-RSRP report is transmitted by MAC CE, which includes   + SSBRI from the list of non-serving cell SSB   + 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, ...  **Concern**: Futurewei, Intel, LG, ... |
| 2.2 | **Proposal 2.H**: On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP  **Alt1.** 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  **Alt2**. Differential L1-RSRP per non-serving cell/serving cell is used:  When more than one SSBRI/L1-RSRP pairs associated with a same PCI are reported, Rel-15 L1-RSRP reporting format is used for pairs associated with the same PCI, i.e. 4-bit differential L1-RSRP(s) calculated relative to the PCI-specific reference (absolute) 7-bit L1-RSRP  **FL note: Need to finalize by selecting one of the alternatives** | **Alt1:** Samsung, MTK, Qualcomm, Ericsson, Docomo, vivo  **Alt2:** ZTE, CMCC, Samsung (2nd preference), Lenovo/MotM, Qualcomm (2nd preference), Sony |
| 2.3 | QCL assumption for paging reception after being activated with only one TCI state associated with PCI different from serving cell [2]  **Alt0.** UE not required to monitor paging assocaited with the newly activated TCI state  **Alt1**. UE to monitor paging in USS associated with the newly activated TCI state [11]  **Alt2**. UE to monitor paging in CSS configured for paging with the newly activated TCI state [offline]  **FL note: We may need to quickly check with RAN2 (also related to the LS reply).**   * **Does the UE need to monitor paging for the newly activated TCI state of a PCI different from the serving cell in RRC connected state?** * **If so, is it on USS or CSS or both?** | **Alt0:** [Samsung]  Concern: NTT Docomo  **Alt1**: Huawei/HiSi, Ericsson, NTT Docomo, MTK  **Alt2**: Huawei/HiSi, NTT Docomo, Apple |
| 2.4 | **Proposal 2.F**: On Rel.17 beam indication enhancements for inter-cell beam management, the supported Rel-17 MAC-CE-based and/or 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), the non-UE dedicated channels/signals (on which such inter-cell beam indication does not apply) comprise:   * All PDCCH receptions on CORESET(s) along with the respective PDSCH receptions and respective PUSCH/PUCCH transmissions if the CORESET(s) is associated with any Type0/0A/1/2[/3] CSS set   **FL note: This is undoubtedly linked with 2.3 (2.3 needs to be resolved first):**   * **If 2.3 is resolved with Alt0 or only Alt1, 2.F seems to be fine as is** * **If 2.3 is resolved with Alt2 (or Alt1 + Alt2), 2.F needs to be refined** | **Support/fine:** MTK, vivo, Lenovo/MotM, Qualcomm, Samsung, LG, AT&T, CMCC, CATT, NTT Docomo  **Resolve issue [2.3] first:** Apple, Huawei/HiSi, Nokia/NSB, Futurewei  **Concern:** Ericsson **(**activated TCI states should not be associated with CORESETs**),** Intel |

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** |
| NTT Docomo | Our view are added in the table.  **Proposal 2.E**: Support. For companies who are supportive event-driven beam reporting, they should be more flexible for MAC CE based or L1 based. We prefer MAC CE based, but also fine with L1 based, because both are benefitial.  **Proposal 2.H**: Support Alt.1. We think Alt.1 has smaller UCI overhead than Alt.2.  **Issue 2.3**: Support Alt.1/2. We have concern on Alt.0. The minimum UE capability UE is activated with TCI states with either serving cell or non-serving cell by MAC CE. When TCI states associated with only non-serving cell are activated for the UE, Alt.0 means UE cannot monitor paging. We think this is an issue.  **Proposal 2.F**: We are fine. |
| vivo | **Proposal 2.E:** Do not support.  **Proposal 2.H:** Support Alt1.  **For issue 2.3**, we prefer Alt0. This is for UE only supporting 1 TCI state. We prefer to add this in the main bullet when have more mature versions.  **Proposal 2.F:** Support. And this may not be necessarily coupled with 2.3 since 2.3 is for the case when only one TCI state is supported but this can at least be clarified for the case when two TCI states are supported. |
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### Issue 3 (beam indication signaling medium)

(done for this meeting – need to wait for issue 4 before discussing multiple BATs)

### Issue 4 (MP-UE)

Table 5 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 values   + FFS: Whether the UE capability values comprises the number of SRS ports, number of UL transmission layers, coherence type, TPMI, or number of SRS resources within one SRS resource set   + FFS: Whether the list of UE capability values can be common across a set of BWPs/CCs * The correspondence between a CSI-RS and/or SSB resource index and the reported list of UE capabilities is determined by the UE (analogous to Rel-15/16) and is informed to NW in a beam reporting instance   + FFS: Whether and how to define the timeline for applying the correspondence   + FFS: How to inform the correspondence to NW in the reporting instance   + FFS: What type of beam reporting instance is considered, e.g. L1-RSRP/L1-SINR/BFRQ * Support multiple codebook –based SRS resource sets with different maximum number of SRS ports   **FL Note: Unless there is some critical, I suggest that companies not propose more refinement on the proposal. To reiterate, “logical index” isn’t agreeable to Ericsson.** | **Support/fine**: Lenovo/MotM, IDC, CATT, NTT Docomo, ...  **Concern**: Intel, ... |
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Table 6 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** |
| NTT Docomo | Support |
| vivo | Regarding “list of UE capability value”, in case that two panels of UE have the same capability, is it possible to have the correspondence between UE panel and SSBRI(s)/CRI(s)? |
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### Issue 5 (MPE mitigation)

Table 7 Summary: issue 5

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| **#** | **Issue** | **Companies’ views** |
| 5.1 | **Proposal 5.C**: On Rel.17 enhancements to facilitate MPE mitigation, for selection of N from a candidate SSB/CSI-RS resource pool:   * Down-select *by* RAN1#107-e between the following alternatives:   + Alt1. Based on L1-RSRP minus P-MPR value for each resource   + Alt2. Based on calculated Virtual PHR for each resource     - Virtual PHR is modified by considering actual P-MPR   + Alt3. Based on L1-RSRP for each resource among the resources with P-MPR values less than a threshold     - FFS: Reporting when there are only less than N P-MPR values under the threshold   + Alt4. No RAN1 spec impact (possibly left to RAN4) * The candidate resource pool corresponds to a CSI-RS/SSB resource set configured via RRC (details up to RAN2)   **FL note: Since we have 1 meeting left, we need to down select or at least narrow down among the above alternatives.**   * **Alt4 is by default one alternative** * **Strive to choose one among Alt1/2/3 so that we may assess the benefit of the scheme against Alt4** | **Alt1**:  **Alt2**:  **Alt3**: NTT Docomo  **Alt4**: vivo |
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Table 8 Additional inputs: issue 5

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| **Company** | **Input** |
| Mod V0 | 1. **Check and update your view in Table 7** 2. **Add more inputs here if needed** |
| NTT Docomo | Our view is updated in the table. We would like to clarify the intention of Alt.3. P-MPR affects UL performance only if there is MPE issue. If several beams with no MPE issue (P-MPR less than a threshold) can be found, N beams with best L1-RSRP can be selected among the beams with no MPE issue. For the FFS part, if there is less than N beams with no MPE issue, e.g., only L beams with no MPE issue, a possible way is to report L beams with no MPE issue and to select the rest N-L beams based on L1-RSRP minus P-MPR. |
| vivo | Support Alt4.  The selection from a candidate SSB/CSI-RS resource pool depends on UE implementation based on L1-RSRP.  The following simulation results show that the performance is very similar/neglegible using L1-RSRP as the metric or using other metric.   * + Case 1(baseline): when MPE event is declared by UE, a modified L1-RSRP is triggered. The UE reports the uplink RSRP that considers the impact of blockage and MPE power back-off for panel/beam switching. gNB selects and determines the panel/beam switching according to the reported uplink RSRP.   + Case 2: when MPE event is declared by UE, a Rel-15 L1-RSRP report is triggered by gNB. The UE reports 4 beam pairs between gNB and UE based on downlink RSRP that considers the impact of blockage. gNB selects and determines the panel/beam switching according to the reported DL RSRP and P-MPR.  1. UL performance with full buffer traffic model for panel/beam switching  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | |  | Dense Urban | | | Indoor Hotspot | | | |  | Mean SE of cell | 5%SE | 50%SE | Mean SE of cell | 5%SE | 50%SE | | Case1 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | | Case2 | 0.04% | -2.10% | -0.23% | -0.04% | 0.00% | 0.01% | |
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### Issue 6 (advanced beam refinement/tracking)

FL observation:

* While most companies observe the importance and potential benefits of specifying advanced beam refinement/tracking especially UE-initiated beam management (beam selection, activation, and reporting/measurement for DL and/or UL), the amount of required work is too large for only one RAN1 meeting. There is virtually no hope in finishing the work even if the group converges to one option (e.g. Opt 1 or 2 of ALT1)
* Meanwhile there are still numerous unresolved problems for issues 1-5 (which, per previous agreements, takes higher precedence given the WID)
* Note that UE-initiated beam management seems to be a popular candidate for Rel-18 MIMO Advanced WI ☺ It is my hope that the outcome of the discussion will be instrumental in drafting the WID for Rel-18 MIMO Advanced.

**Proposed conclusion 6.1**: Discussion on advanced beam refinement/tracking (“issue 6”) is suspended for the remaining of Rel-17 NR\_FeMIMO multi-beam enhancement (due to lack of time).

Table 9 Additional inputs: issue 8

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| **Company** | **Input** |
| Mod V0 | **Please share your input, if any, on proposed conclusion 6.1** |
| NTT Docomo | It is unfortunate, but we can understand. We think explicit conclusion is not needed in this meeting, but we can deprioritize the discussion order. |
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