**3GPP TSG RAN WG1 #104-e R1-2101913**

**e-Meeting, January 25th – February 5th, 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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| * 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 |

## Summary and proposals

The summary and proposals are based on the content of the previous FL summaries R1-2101185 (preparation) and R1-2101856 (round 1).

### Issue 1 (Rel.17 unified TCI framework)

Table 1 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 1.6 | PL-RS in relation to UL TCI state and channels | Alternatives:   * **PL-RS included in UL TCI state:** IDC, Ericsson (optional for DL RS), Apple (only valid when SRS is configured for beam indication), vivo (in case of DL RS in TCI state), MTK (for no PL-RS configured, and DL CSI-RS or SSB), Intel, AT&T, OPPO (separate RS), Fraunhofer IIS/HHI (separate RS), Qualcomm, Lenovo/MoM, Xiaomi, NTT Docomo, OPPO, Nokia/NSB (QCL-TypeD RS if periodic and no PL-RS configured /associated), LG * **PL-RS associated with UL TCI state:** Futurewei, Spreadtrum, Nokia/NSB, Huawei/HiSi, MTK, Sony, Qualcomm (separate field in the same DCI), CATT, NTT Docomo, ZTE, CMCC * **PL-RS not associated with UL TCI state:** Ericsson (in case of UL RS in TCI state) * **Use Rel-16 PL-RS framework:** vivo (for UL RS in TCI state)   MAC CE configures association between activated TCI states and PL-RS/PC: CATT, MTK(PL-RS only), Sony(only PL-RS) | |

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| **Proposal 1.4**: On Rel.17 unified TCI framework:   * When a PL-RS is not explicitly associated or included in the UL or, if applicable, joint TCI state, a periodic DL RS used as a source RS for determining spatial TX filter ~~is~~ in the UL or, if applicable, joint TCI state, ~~the periodic DL RS~~ is the PL-RS * ~~When a periodic DL RS used as a source RS for determining spatial TX filter is not configured in the UL or, if applicable, joint TCI state~~Otherwise, select one of the following alternatives by RAN1#104bis-e:   + Alt1. PL-RS is always included in UL TCI state or (if applicable) joint TCI state   + Alt2. PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state   + Alt3. Reuse Rel.16 procedure (MAC CE+DCI based) to indicate PL-RS for UL transmission without enhancement   + Alt4. UE calculates path-loss based on periodic DL RS configured as the QCL/spatialRelationInfo source of the RS in UL TCI state or (if applicable) joint TCI state |

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| Action: Interested companies are encouraged to provide their inputs on the proposal  Goal: Finalize the proposal to be ready for endorsement |

Table 2 Inputs: issue 1

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| **Company** | **Input** |
| Moderator | 1.1: Starting from the last version before it was removed from Wed checkpoint list (Dr. Bo’s version) |
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### Issue 2 (L1/L2-centric inter-cell mobility)

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.2 | Type of beam metric for measurement and reporting:  L1-RSRP or L3-RSRP | Alternatives**:**   * **L1-RSRP (19):** vivo, MTK, Samsung, Qualcomm (L3 can reuse existing), Intel (intra-DU can re-use L1-RSRP), Xiaomi, Sony, NTT Docomo, ZTE, Ericsson, Nokia/NSB, Futurewei, Huawei/HiSi, IDC, APT, ASUS, CMCC * **L3-RSRP (4):** OPPO, Lenovo/MoM, Xiaomi (L3-RSRP only for triggering beam measurement of non-serving cell) * **Hybrid L1+L3-RSRP (2):** Apple, CATT (with SD filter L3-RSRP) |

Note that this issue is relevant not only for L1/L2-centric inter-cell mobility, but also for inter-cell mTRP. Based on the above summary, the following proposals are made:

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| **Proposal 2.1**: On Rel.17 multi beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP:   * Rel.15 L1-RSRP is used as reporting quantity for measurement and reporting of non-serving-cell(s)   + At least Rel.15 SS-RSRP calculated from SSB of non-serving cell(s) is supported   + FFS: The support of Rel.15 CSI-RSRP depending on whether CSI-RS (for e.g. RRM and/or tracking) is supported as a measurement RS for L1/L2-centric inter-cell mobility and/or inter-cell mTRP * FFS: If other reporting quantities are supported, e.g. L3-RSRP, hybrid L1/L3-RSRP |

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| Action: Interested companies are encouraged to provide their inputs on the proposal  Goal: Finalize the proposal to be ready for endorsement |

Table 4 Inputs: issue 2

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### Issue 3 (beam indication signaling medium)

Table 5 Summary: issue 3

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 3.1 | Beam application time definition:  Alt1: Measured from DCI reception  Alt2: Measured from ACK transmission | **Alt1 (DCI) (7):** Spreadtrum, Xiaomi, Ericsson, CATT, MTK, NEC, Samsung  **Alt2 (ACK) (17):** IDC, Lenovo/MoM, Fujitsu, Nokia/NSB, CMCC, Apple, Huawei/HiSi, ZTE, vivo, Intel, Sony, Qualcomm, NTT Docomo, APT  **Alt1 and Alt 2:** OPPO (Since Alt1 considers the requirement of UE and Alt2 considers the requirement of gNB side), LG | |
| 3.4 | Support for additional DCI formats for Rel.17 unified TCI framework beam indication (TCI state update) | DCI formats 1\_1/1\_2 without DL assignment:   * **Yes (18)**: OPPO, Fujitsu, Spreadtrum, Nokia/NSB, CATT, vivo (at least for UL-only TCI), MTK, Qualcomm, Samsung, Apple (ACK/NACK mechanism is needed), vivo, Lenovo/MoM, Convida, NTT Docomo, ZTE (ACK/NACK is needed), NEC (ACK/NACK needed) * **No (4)**: Ericsson, Huawei/HiSi, LG   DCI formats 0\_1/0\_2 with UL grant:   * **Yes (10)**: IDC, Nokia/NSB, Xiaomi (at least for UL-only TCI), ZTE (at least for UL-only TCI), MTK, LGE, Intel, Sony (Study), Qualcomm * **No (12)**: OPPO, CMCC, Ericsson, Huawei/HiSi, Convida, Apple, vivo, Spreadtrum, CATT, NTT Docomo, NEC   Dedicated DCI format for beam indication, with dedicated ACK based on SPS PDSCH release:   * **Yes (15)**: Futurewei, ZTE, CATT, Intel, Sony, NTT Docomo(keep the same DCI payload as existing DCI format), OPPO (based on format 1\_0 without DL assignment), Samsung, Nokia/NSB (based on format 0\_1/0\_2 without UL grant), Qualcomm, Lenovo/MoM, APT (based on SPS or CG release DCI), NEC * **No (8)**: Ericsson, MTK, Convida, Apple, vivo, Huawei/HiSi, LG   **Support extending existing DCI formats for UL-only TCI**: APT | |

Additional DCI

From Table 5, the reuse of DCI formats 0\_1/0\_2 with UL grant is unlikely agreeable (10 support vs 12 oppose). The remaining alternatives should be down selected

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| **Proposal 3.1**: On the Rel.17 DCI-based beam indication, in RAN1#104bis-e, down-select one of the following alternatives regarding the support of DCI format(s) for beam indication in addition to the agreed DCI formats 1\_1/1\_2 with DL assignment (in RAN1#103-e):   * Alt0: No additional DCI format is supported * Alt1: DCI formats 1\_1 and 1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI   + FFS: support DCI acknowledgment mechanism, e.g. based on SPS PDSCH release, based on triggered SRS   + FFS: How to identify DCI formats 1\_1/1\_2 used for beam indication only, not scheduling a PDSCH reception, indicating a SPS PDSCH release or indicating SCell dormancy * Alt2: Dedicated DCI format other than 1\_1/1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI   + Support DCI acknowledgment mechanism based on SPS PDSCH release   + FFS: If the format is based on an existing DCI format, how to identify the DCI format used for beam indication only |

Beam Application Time (BAT)

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| Previous agreement (RAN1#103-e):  On Rel.17 DCI-based beam indication:   * Regarding application time of the beam indication: if beam indication is received, down-select from the following:   + Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication   + Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication   + FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y * FFS: When to apply the minimum indication delay (e.g., when the newly indicated beam is different with the previously indicated beam) |

The main arguments for Alt1 (assuming the agreed DCI formats 1\_1/1\_2 with DL assignment):

* It tends to result in lower beam application latency than Alt2
* Unlike Alt2, for the agreed DCI formats 1\_1/1\_2 with DL assignment, it allows the updated TCI state (signaled in the DCI) to be used for the DL assignment (PDSCH reception) associated with the beam indication DCI provided that the offset between the DCI and the PDSCH resources used for the DL assignment is larger than the threshold. This is not possible in Alt2 since the updated TCI state can be active only after the ACK transmission (hence after the DL assignment).

The main arguments for Alt2 (assuming the agreed DCI formats 1\_1/1\_2 with DL assignment):

* Unlike Alt1 where potential misalignment between gNB and UE assumptions on the TCI state can occur if the DCI is not successfully decoded, Alt2 ensures that the gNB and the UE are aligned (since the gNB can assume that the TCI state update is successfully received after receiving the ACK from the UE).

Assessment: It is argued that since PDCCH error rate is around 1%, the probability of TCI state assumption misalignment associated with Alt1 is 1% (non-negligible), thus Alt2 is preferred.

* However, this reasoning ignores that the misalignment only occurs between the DCI reception and ACK transmission –typically a significantly smaller fraction of the overall UE data traffic even if the UE receives DL assignment in every slot.
* Furthermore, this misalignment (only in a relatively small time period) only occurs for other PDCCH transmission (than the beam indication DCI) and other PDSCH/PUSCH transmissions (not associated with the DL assignment). It does not apply to the DL assignment associated with the beam indication DCI. Nor does it apply to PUCCH resource used for the ACK.
* Furthermore, it is argued that since BAT is configured by the gNB (given the UE capability), the gNB can configure the BAT depending on factors, e.g. UE data traffic, resource allocations, such that the chosen value avoids or minimizes the misalignment while still ensuring lower bema application latency compared to Alt2. Obviously a sufficiently large BAT for Alt1 can replicate the effect of Alt2, but the converse doesn’t always hold.

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| [Placeholder for proposal 3.2] |

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| Action: Interested companies are encouraged to provide their inputs on:   * Proposal 3.1 on DCI format * Beam application time (BAT): after summarizing the arguments from both sides, companies are encouraged to respond and decide between Alt1 vs Alt2   Goal:   * Proposal 3.1: Finalize the proposal for endorsement * BAT: Arrive at a proposal to down select Alt1 vs Alt2 |

Table 6 Inputs: issue 3

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| **Company** | **Input** |
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### Issue 4 (MP-UE)

Table 7 Summary: issue 4

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 4.3 | Support for NW-initiated UL panel selection and activation | NW-initiated UL panel selection (of one) and activation (of ≥1)   * **Yes**: IDC, Huawei/HiSi, ZTE, LGE, NTT Docomo,CMCC * **No**: OPPO, Fraunhofer IIS/HHI, CATT, MTK, Intel, Sony, Xiaomi, Qualcomm (NW can initiate selection within active panels but not activation), Spreadtrum, Nokia/NSB   NW-to-MPUE signaling of panel selection/activation:   * **Yes**: NTT Docomo, Lenovo/MoM, Xiaomi, APT, IDC (panel ID in TCI state), Samsung (in case of MPE), CATT, APT, vivo, Qualcomm (NW can signal which active panel to use but not activation), Spreadtrum (select among active panels), Nokia/NSB, Huawei/HiSi (with UE confirmation/rejection), LG, CMCC * **No**: OPPO | |

In RAN1#103-e, the support for UE-initiated UL panel selection/activation was agreed, with FFS on whether NW-initiated panel selection/activation is also supported. This FFS needs to be resolved early.

Based on the above summary, the following proposals are made:

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| **Proposal 4.1**: On Rel.17 enhancement for facilitating fast uplink panel selection, support NW-to-MPUE signalling of UE panel selection and activation:   * For UE panel selection, Rel.17 DCI-based TCI state update (beam indication) is used * For UE panel activation, Rel.17 MAC-CE-based TCI state activation is used * FFS: If additional specification support in TCI state definition to accommodate UE panel is needed or not, and if so, the exact scheme |

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| Action: Interested companies are encouraged to provide their inputs on proposal 4.1  Goal: Finalize the proposal to be ready for endorsement |

Table 8 Inputs: issue 4

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| **Company** | **Input** |
| Moderator | 4.1: This proposal is to ensure that there is beam indication support. The FFS addresses additional TCI state definition for panel. This also depends on what panel entails. Agreeing to this proposal doesn’t imply that we agree on a new TCI state signaling scheme. Similar to the previous agreement on UE-initiated panel selection/activation. |
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### Issue 5 (MPE mitigation)

Table 9 Summary: issue 5

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 5.3 | Any additional reporting content:   * Alt0: no additional reporting content * Alt1: Additional reporting content | **Alt0**: Ericsson, Intel, Xiaomi, MTK, Spreadtrum, Lenovo/MoM, Huawei/HiSi, APT  **Alt1**:   * CRI/SSBRI + L1-RSRP/L1-SINR + P-MPR: OPPO, MediaTek, Nokia/NSB, IDC * CRI/SSBRI + L1-RSRP/L1-SINR + virtual PHR: Nokia/NSB, Apple, Convida, CMCC * CRI/SSBRI + L1-RSRP/L1-SINR + panel ID: LG, CMCC * CRI/SSBRI + virtual PHR: ZTE, Convida * CRI/SSBRI + UL RSRP + panel ID: Qualcomm * CRI/SSBRI + new/additional param. (indicating MPE): CMCC * P-MPR + panel-ID: vivo, Sony (panel-specific), IDC * P-MPR + alternative panel or UL TX beam: Nokia/NSB * ID of preferred/non-preferred panel: LGE | |

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| **Previous agreements**:  [RAN1#103-e]  On UE reporting for MPE mitigation for Rel-17, investigate and, if needed, specify the following:   * … * Any additional reporting content: down-select from the following in RAN1#104-e   + Alt0: no additional reporting content   + Alt1: Additional reporting content is included (for example P-MPR + L1-RSRP, virtual PHR + L1-RSRP, L1-RSRP/SINR with and without MPE effect, virtual PHR, P-MPR or virtual PHR + CRI/SSBRI, estimated max UL RSRP)     - Note: Other options are not precluded     - FFS: Whether the above reporting is triggered by UE or configured by NW   [RAN1#104-e]  On Rel.17 enhancements to facilitate MPE mitigation,   * On further enhancing the P-MPR report in Rel.16 (already agreed RAN4 framework, including triggering), down select between beam-level and panel-select reporting * On SSBRI(s)/CRI(s) and/or indication of panel selection, focus study on the following:   + Reporting of at least SSBRI(s)/CRI(s) to indicate gNB beam(s) that is feasible for UL transmission: additional reporting quantities are FFS   + Reporting of at least an indicator associated with a UE ‘panel’ that is feasible for UL transmission: additional reporting quantities are FFS * Note: Just as agreed in RAN1#103-e, the purpose is to assess whether specification is needed or not |

It was agreed that we have to down-select the alternatives for additional reporting content in this meeting. From the summary, L1-RSRP/SINR and virtual PHR are the quantities supported by more companies.

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| **Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation, perform study and, if needed, specify the following reporting quantities in addition to the Rel.16-based P-MPR and/or SSBRI(s)/CRI(s)/panel indication:   * L1-RSRP/SINR associated with each of the reported SSBRI(s)/CRI(s)/panel indication (if configured) * Virtual PHR   Note: Performing study and, if needed, specifying Rel.16 based P-MPR and SSBRI(s)/CRI(s)/panel indication was already agreed |

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| Action: Interested companies are encouraged to provide their inputs on proposal 4.1  Goal: Finalize the proposal to be ready for endorsement |

Table 10 Inputs: issue 5

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| **Company** | **Input** |
| Moderator | 5.1: We need to start narrowing down options for study on additional quantities. From the summary, this could be a good starting point |
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### Issue 6 (beam refinement/tracking)

After round-1 discussion was concluded, below is proposal 6.1 revised based on companies’ inputs (a sub-bullet on the second bullet was added to address inquiries).

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| **Proposal 6.1**: On Rel.17 enhancements based on the unified TCI framework, perform study and, if needed, specify the following:   * Beam management with reduced DL signaling (e.g. beam update based on reporting, beam measurement and report triggered by beam indication, multi-SSB indication, semi-static beam transition configuration, UE-initiated beam update/activation)   + Candidate schemes will be down selected or, if possible, combined * Reducing activation delay of TCI states (including other WGs, e.g. RAN4)   + On RAN4-related matters, assessment/study phase can be done in RAN1. If RAN4-based enhancements are found necessary, a LS to RAN4 will be sent (to prepare RAN4 work)   Note: Given its dependence on the maturity of other issues (1 to 5), when to start the work and how much work is done on issue 6 should depend on the progress on the other issues. |

**Support**: Futurewei (clarify 2nd bullet), MTK, Samsung, OPPO, Apple, Intel, NTT Docomo, Qualcomm (clarify 2nd bullet), Ericsson, IDC, Spreadtrum (after other issues progress enough), Xiaomi, Nokia/NSB (clarify 2nd bullet), Convida (after other issues progress enough), Lenovo/MoM

**Not support**: ZTE, Huawei/HiSi, vivo

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| Action: Interested companies are encouraged to share inputs on refining the text for endorsement  Goal: Finalize the proposal to be ready for endorsement |

Table 11 Inputs: issue 6

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