**3GPP TSG RAN WG1 #106bis-e R1-2110492**

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

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#2 for multi-beam enhancement: ROUND 1

**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
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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 | Max number of configured TCI states | **Define max # configured TCI states:*** **Joint/DL TCI apart from UL TCI:** ...
* **Total number across all types of TCI (joint, DL, and UL):** ...

**Define max # configured TCI states per BWP/CC**:* **Yes**: ...
* **No**: ...
 |
| 1.9 | For separate TCI, UL TCI state poolAlt1: Shared pool with joint/DL TCI stateAlt2: Separate pool Note: Strictly speaking, this could be decided in RAN2. Therefore, if there is no consensus, this will be left to RAN2 | **Alt1:*** **Support (12)**: vivo, Spreadtrum, Samsung, Xiaomi, ZTE, Qualcomm, MTK, Convida, NTT Docomo, Intel, CATT, TCL
* **Concern**:

**Alt2**: * **Support** (11): CMCC, Ericsson, Futurewei, Huawei/HiSi, Fraunhofer IIS/HHI, IDC, Sony, Apple, AT&T
* **Concern**:
 |
| 1.10 | 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 (9):** Spreadtrum, OPPO, Intel, Apple, Sony, Ericsson, Huawei/HiSi, Futurewei

SRS for BM, optionally with TRS as QCL Type-A source RS* **Yes (8):** ZTE, IDC, Spreadtrum, Samsung, Convida, Nokia/NSB, vivo, Xiaomi
* **No (11):** Sony, OPPO, Fraunhofer IIS/HHI, MTK, Intel, Ericsson, Huawei/HiSi, LG, Futurewei
 |
| 1.11 | BFR enhancement for unified TCI: X symbols after the UE receives the BFRR, the new/updated QCL source RS applies to both UE-dedicated PDCCH and PDSCH | **Yes**: Apple, NEC**No**: |
| 1.12 | BFR enhancement for unified TCI: can BFD RS share the same indicated Rel-17 TCI state as UE-dedicated PDSCH/PDCCH? | **Yes**: NEC, NTT Docomo, Convida, Apple (only CSI-RS without QCL indication, but we suggest to make it in a general way), Huawei, HiSilicon**No**:  |
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Based on the above observation, the following moderator proposals can be made:

**Proposal 1.A**: On Rel.17 unified TCI framework, for Rel-17 unified TCI, the largest number of configured TCI states (including joint TCI state(s), DL-only TCI state(s), and/or UL-only TCI state(s)) ... [after more discussion]

**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

**Proposal 1.B.2:** On Rel.17 unified TCI framework, for Rel-17 unified TCI, a list of 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) is configured via RRC.

**Proposal 1.G**: On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, when both PL-RS and UL TCI spatial relation RS are not the same CSI-RS for BM, “beam alignment” also pertains to the following events:

* The PL-RS is identical to the QCL Type-D or spatial relation RS of UL or (if applicable) joint TCI spatial relation RS
* The QCL Type-D RS of PL-RS is identical to the UL or (if applicable) joint TCI spatial relation RS
* The QCL Type-D RS of PL-RS is identical to the QCL Type-D or spatial relation RS of UL or (if applicable) joint TCI spatial relation RS
* [When UL spatial relation RS of UL TCI spatial relation RS is a BM SRS resource, the PL-RS or the QCL Type-D RS of PL-RS is identical to the configured PL-RS of the SRS resource]

**Proposal 1.H**: On Rel.17 unified TCI framework, 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 can be associated with an UL or (if applicable) joint TCI state per BWP via RRC

Table 2 Additional inputs: issue 1

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| **Company** | **Input** |
| Mod V0 | **1) Check and update your view Table 1****2) Share your inputs on the above FL proposals esp re*** **New proposals 1.B.1, 1.B.2**
* **Wording refinement for proposals 1.G and 1.H (changed ‘is’ to ‘can be’). We have already discussed these two for 4 weeks!**
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### Issue 2 (inter-cell beam management)

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.5 | Whether to support event-driven inter-cell beam reporting and if so the event definition* Alt1. Support L1-based event-driven beam reporting for inter-cell beam management and inter-cell mTRP
* Alt2. Support MAC CE based event-driven beam reporting for inter-cell beam management and inter-cell mTRP
* Alt3. In Rel-17, event-driven beam reporting is not supported for inter-cell beam management and inter-cell mTRP

Note: Since it was agreed to finalize this issue in RAN1#106bis-e, if there is no consensus or if Alt1 and Alt2 proponents cannot converge, Alt3 is by default the outcome for Rel-17 | **Alt1**: * Support (9): Huawei/HiSi, Xiaomi, Intel, Sony, LG, Samsung, Qualcomm (2nd preference), Futurewei
* Concern:

**Alt2**: * Support (11): ZTE, Lenovo/MotM, CATT, Xiaomi, NTT Docomo, Nokia/NSB, Apple, Qualcomm (1st preference), Convida
* Concern:

**Alt3 (4)**: OPPO, vivo, Ericsson, MTK |
| 2.6 | UCI design for L1-RSRP reporting: Reuse Rel-15 L1-RSRP table | **Yes:** Samsung, MTK, Qualcomm, Ericsson, ZTE, FGI/APT, Huawei, HiSilicon, CATT**No:**  |
| 2.7 | UCI design for L1-RSRP reporting: For K>1, reuse (K-1) Rel-15 differential L1-RSRP() relative to the first L1-RSRP value | **Yes:** Samsung, MTK, Qualcomm, Ericsson**No:** ZTE (Differential L1-RSRP per non-serving cell/serving cell), CMCC (same as ZTE) |
| 2.8 | QCL assumption for paging reception after being activated with only one TCI state associated with PCI different from serving cell [2]Alt-1: UE to monitor paging in USS with the newly activated TCI state [11]Alt-2: UE to monitor paging in CSS configured for paging with the newly activated TCI state [offline] | Alt-1: Huawei, HiSilicon, EricssonAlt-2: Huawei, HiSilicon |

Proposals 2.A and 2.B are taken from the final outcome of the offline discussion [1].

The following observation can be made:

* 2.3: There is no consensus in adding the additional restriction
* 2.4: Alt1 represents the super-majority view
* 2.5: Among the proponents of event-driven reporting, there is no consensus on whether to support L1-based or MAC-CE-based solution

Based on the above observation, the following moderator proposals can be made:

**Proposed conclusion 2.A**: On Rel-17 beam indication enhancements for inter-cell beam management, the supported number of physical cell IDs different from that of the serving cell that are associated with activated TCI states for 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) will be decided as a part of UE feature discussion.

* Decide in conjunction with inter-cell mTRP, where the candidate value(s) include at least 1

**Proposed conclusion 2.B**: On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP, for Rel-17 discussion purpose, RAN1 assumes that the reception of signals from TRPs with PCIs different from the serving cell compared to that for serving cell is within one CP length associated with the SCS of the active DL BWP.

* [For the case when the Rx signals from TRPs with PCIs different from the serving cell are within SMTC, legacy UE behavior remains]

**Proposal 2.D**: On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP, NMAX (the maximum number of RRC-configured PCIs different from the serving cell for measurement/reporting) is up to UE capability with candidate values of 1 and X.

* Note: X as agreed in AI 8.1.2.2
* When NMAXis configured to be X, the UE is RRC-configured for L1-RSRP measurement with up to X PCIs different from the serving cell PCI
* Additional restriction may be added by RAN4
* FFS: UE measurement behaviour when SSBs associated with different PCIs overlap, including whether this is up to UE capability

**Proposal 2.E**: On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP, [event-driven – after more discussion]

**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 beam indication does not apply) comprise:

* All PDCCH receptions on CORESET(s) along with the respective PDSCH receptions if the CORESET(s) is associated with any Type0/0A/1/2 CSS set

**Proposal 2.G**: On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP:

* The L1-RSRP reporting reuses Rel-15 L1-RSRP table
* 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 7-bit L1-RSRP

Table 4 Additional inputs: issue 2

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| **Company** | **Input** |
| Mod V0 | **Proposals 2.A, 2.B, 2.D are relatively stable apart from some minor issues****1) Check and update your view in Table 3 (esp issue 2.5 per proponents’ strong request to continue discussion)****2) Share your inputs on the above FL proposals, especially re*** **Red text in proposed conclusion 2.B**
* **Any refinement needed for proposal 2.D**
* **New proposal 2.F (on the definition of non-UE-dedciated channels/signals raised by MTK)**
* **New proposal 2.G (on L1-RSRP reporting format)**
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### Issue 3 (beam indication signaling medium)

Table 5 Summary: issue 3

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| **#** | **Issue** | **Companies’ views** |
| 3.1 | BAT (Y) for CA:* Alt1: The first slot and the Y symbols are both determined on the carrier with the smallest SCS among the carrier(s) applying the beam indication
* Alt2: The first slot and the Y symbols are both determined on the carrier with smallest SCS among the carrier(s) applying the beam indication and the UL carrier carrying the acknowledgment
* Alt3: The first slot and the Y symbols are both determined on the UL carrier carrying the acknowledgment.
 | **Alt1**: OPPO, Lenovo/MotM, Ericsson, CATT, CMCC, Xiaomi, NTT Docomo, Nokia/NSB, Huawei/HiSi, Spreadtrum, MTK, Intel, Apple, Qualcomm, Samsung (2nd pref), TCL, **Alt2**: vivo, Samsung (1st), APT/FGI**Alt3**: ZTE, Sony |
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**Proposal 3.A**: On Rel-17 DCI-based beam indication, regarding application time of the beam indication for CA, the first slot and the Y symbols are both determined on the carrier with the smallest SCS among the carrier(s) applying the beam indication.

* [Note: For Rel-17 MAC-CE based beam indication (when only a singleTCI state is activated), following the Rel-15 MAC-CE ACK timeline, the single activated TCI state is applied starting from the first slot that is 3ms after the ACK corresponding to the PDSCH carrying the MAC-CE, wherein the first slot is based on the UL carrier carrying the acknowledgment]
* [Value(s) of Y are configured per SCS and dependent on SCS of target BWP, one of the configured Y symbols is used]

Table 6 Additional inputs: issue 3

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| **Company** | **Input** |
| Mod V0 | **1) Share your inputs on the above FL proposal 3.A especially on the red texts** |
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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 | **Support**: Huawei/HiSi, IDC, Spreadtrum, vivo, Fujitsu, Lenovo/MotM, Fraunhofer IIS/HHI, NTT Docomo, Sony, AT&T, Apple, LG, Qualcomm, ZTE, Xiaomi, Samsung, Nokia/NSB, MTK, CMCC, **Not support**: Ericsson, OPPO, Intel |
| 4.2 | Multiple SRS resource sets with different SRS #ports | **#SRS resource sets*** **2**: Samsung, OPPO, Fraunhofer IIS/HHI, ZTE
* **3**: Samsung, Qualcomm

**#SRS resources in each set:*** **UE reporting**: vivo, Qualcomm

**#SRS ports in each set*** **1, 2, 4**: Samsung, Qualcomm, ZTE
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The following observation can be made:

* 4.1: Scheme 1 still represents the majority view. Among the proponents of Scheme 2, it is unclear if there is any convergence on the option (note that Scheme 2 includes 3 different schemes). Given the current situation, it seems proper to proceed with Scheme 1 (previously supported by some supporters of Scheme 2 as well).

Based on the above observation, the following moderator proposals can be made:

**Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection,

* At least one logical index is introduced that is associated with a UE capability
	+ Support UE reporting of a UE capability for each logical index
	+ FFS: Whether the UE capability comprises the number of SRS ports, number of UL transmission layers, coherence type, or TPMI
	+ The logical index and the associated UE capability can be common across a set of BWPs/CCs based on UE capability
* The correspondence between a CSI-RS and/or SSB resource index and a logical index is determined by the UE (analogous to Rel-15/16) and is informed to NW in a beam reporting instance
	+ FFS: The need for specifying timeline for correspondence signaling, e.g. the correspondence is applied X symbols after receiving gNB acknowledgment for the report
	+ FFS: Detailed design
* Support multiple codebook –based SRS resource sets with different maximum number of SRS ports
	+ The indicated SRI is based on the SRS resources corresponding to one SRS resource set associated to a logical index, where the SRS resource set should be aligned with the UE capability for the logical index
	+ [Note: In Rel-17, from RAN1 perspective, there is no further enhancement on the simultaneous transmission for the SRS] vs. [UE shall not expect gNB to trigger the SRS in different resource sets overlapped in time domain]

Table 8 Additional inputs: issue 4

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| **Company** | **Input** |
| Mod V0 | **1) Check and update your view in Table 7** **2) Share your input on proposal 4.A especially re*** **the red text between brackets**
* **There are too many FFSs (not including issue 4.2). Suggest how to resolve the FFSs (or remove them)**
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### Issue 5 (MPE mitigation)

Table 9 Summary: issue 5

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| **#** | **Issue** | **Companies’ views** |
| 5.1 | Proposal 5.A | **Support**: ZTE, Samsung, CATT, CMCC, Xiaomi, Intel, NTT Docomo, Ericsson, Sony, Nokia/NSB, Apple, Qualcomm, LG, IDC, MTK, Spreadtrum**Not support**: vivo, Huawei, HiSilicon |
| 5.2 | Proposal 5.B | **Support**: ZTE, Samsung, CATT, CMCC, Xiaomi, Intel, NTT Docomo, Ericsson, Sony, Nokia/NSB, Apple, Qualcomm, LG, IDC, MTK, vivo, Huawei, HiSilicon, Spreadtrum**Not support**:  |
| 5.3 | How to perform selection of N from a candidate SSB/CSI-RS resource pool and how the candidate resource pool is configured  | Selection of N is based on:* **TCI state quality**: OPPO
* **TCI state group quality**: IDC
* **L1-RSRP and P-MPR**: Ericsson, NTT Docomo, Qualcomm, MTK
* **Virtual PHR**: Nokia/NSB, ZTE, Convida

Candidate resource pool:* **Configured via RRC**: CATT, ZTE
* **Configured via RRC using CSI report config**: Samsung, [Nokia/NSB], MTK, IDC
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**Proposal 5.A**: On Rel.17 enhancements to facilitate MPE mitigation, confirm the following working assumption as an agreement with the following refinement (highlighted in red):

* *For each P-MPR value, up to M SSBRI(s)/CRI(s), where the SSBRI(s)/CRI(s) is selected by the UE from a candidate SSB/CSI-RS resource pool (FFS: how to perform the selection)*
	+ *~~FFS: The supported value(s) of M~~ Support only M=1*

**Proposal 5.B**: On Rel.17 enhancements to facilitate MPE mitigation, support N=1, 2, 3, and 4

* N is defined as the number of reported measurements
* UE reports supported largest N value as a UE capability

**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 two alternatives:
	+ Alt1. Based on L1-RSRP offset by P-MPR for each resource
	+ Alt2. Based on calculated Virtual PHR for each resource
* The candidate resource pool is configured vua RRC using CSI framework

Table 10 Additional inputs: issue 5

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| **Company** | **Input** |
| Mod V0 | 1. **Check Table 9 (if your views are correctly captured)**
2. **If you have inputs on the wording of the proposals 5.A and 5.B**
3. **Share your view on the new proposal 5.C**
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### Issue 6 (advanced beam refinement/tracking)

Later round(s)