**3GPP TSG RAN WG1 #106bis-e R1-2109466**

**e-Meeting, October 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
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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

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)

Table 1 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** |
| 1.1 | Offline proposal 1.A (below)Note: The wording of proposal can be further refined (please describe in Table 2) | **Max 8 TCI codepoints in DCI (same as Rel.15/16):*** **Support:** ZTE, vivo, Lenovo/MotM, CMCC, APT/FGI, Nokia/NSB, LG, Ericsson, Apple, OPPO, Intel, MTK, Fujitsu, Qualcomm, IDC, Spreadtrum, NTT Docomo
* **No (increase to 16):** Samsung

**Max total 128 configured TCI states (same as Rel.15/16):*** **Support:** vivo, Lenovo/MotM, CMCC, Nokia/NSB, OPPO, MTK, Fujitsu, Qualcomm, IDC, Spreadtrum,
* **No (increase to 256):** ZTE, Ericsson, Samsung, APT/FGI, LG, Intel, NTT Docomo
 |
| 1.2 | Offline proposal 1.B (below)Note: The wording of proposal can be further refined (please describe in Table 2) | **Support**: Ericsson, Samsung, MTK, Intel (intra-cell only), AT&T, Apple, Intel, Spreadtrum, CMCC, ZTE, Fujitsu, Qualcomm, Sony, Lenovo/MotM, **Not support**: |
| 1.3 | Offline proposal 1.C.1 and 1.C.2 (below)Note: The wording of proposal can be further refined (please describe in Table 2) | **1.C.1:*** **Support**: MTK, Samsung, ZTE, Intel, vivo, CMCC, Fujitsu, Lenovo/MotM, NTT Docomo, Qualcomm
* **Not support**:

**1.C.2:*** **Support**: MTK, Samsung, ZTE, Intel, vivo, CMCC, Fujitsu, Qualcomm, Ericsson
* **Not support**:
 |
| 1.4 | Offline proposal 1.D (below)Note: If there is no consensus in removing the brackets, spec editor(s) will eventually assume that the bracketed text doesn’t exist in the agreement. | **Support**: vivo, NTT Docomo, Nokia/NSB, Samsung, Sony, Spreadtrum, MTK, Convida, Intel, vivo, CMCC, ZTE, Fujitsu, Lenovo/MotM, IDC, Qualcomm**Not support**: Apple (replace “configured” by “CCs/BWPs at least within a band”), Ericsson  |
| 1.5 | Offline proposal 1.E (below)Note: The wording of proposal can be further refined (please describe in Table 2) | **Support**: Spreadrum, MTK, Qualcomm, vivo, Intel, Samsung, CMCC, [ZTE], Fujitsu, Lenovo/MotM, NTT Docomo, Ericsson**Not support**: |
| 1.6 | Offline proposal 1.F (below)Note: The wording of proposal can be further refined (please describe in Table 2) | **Support**: Ericsson (Opt 1), MTK, Intel (Opt2), Apple (Opt1), vivo, Spreadtrum, Samsung, CMCC, ZTE, Fujitsu, Lenovo/MotM, IDC, NTT Docomo, Qualcomm**Not support**: |
| 1.7 | Offline proposal 1.G (below)Note: The wording of proposal can be further refined (please describe in Table 2) | **Support**: OPPO, Lenovo/MotM, Fraunhofer IIS/HHI, Nokia/NSB, Samsung, MTK, Qualcomm, Intel, CMCC, Fujitsu, IDC, NTT Docomo**Not support**: ZTE, vivo |
| 1.8 | Offline proposal 1.H (below)Note: The wording of proposal can be further refined (please describe in Table 2) | **Support (RRC + MAC CE)**: ZTE, CATT, Nokia/NSB, Samsung, Qualcomm, MTK, CMCC, ZTE, Fujitsu, IDC **Not support (RRC only)**: vivo, Intel, Ericsson, Spreadtrum  |
| 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  | **Alt1 (12)**: vivo, Spreadtrum, Samsung, Xiaomi, ZTE, Qualcomm, MTK, Convida, NTT Docomo, Intel, CATT, TCL**Alt2 (10)**: CMCC, Ericsson, Futurewei, Huawei/HiSi, Fraunhofer IIS/HHI, IDC, Sony, Apple |
| 1.10 | Additional source RS type for DL QCL Type-D reference for DL common UE-dedicated reception on PDSCH and all/subset of CORESETsNote: CSI-RS for tracking (TRS) and CSI-RS for BM have been agreedNote: There are currently two interpretations on the agreement regarding CSI-RS for CSI: 1) Agreeing on reusing Rel-15/16 QCL rules implies CSI-RS for CSI is also agreed, 2) Only CSI-RS for tracking and BM were listed in the agreement, so CSI-RS for CSI is not yet agreed | SSB, with TRS as QCL Type-A source RS* **Yes (4):** ZTE, Samsung, MTK, vivo, Qualcomm
* **No (8):** Spreadtrum, OPPO, Intel, Apple, Sony, Ericsson, Huawei/HiSi

SRS for BM, optionally with TRS as QCL Type-A source RS* **Yes (8):** ZTE, IDC, Spreadtrum, Samsung, Convida, Nokia/NSB, vivo
* **No (10):** Sony, OPPO, Fraunhofer IIS/HHI, MTK, Intel, Ericsson, Huawei/HiSi, LG
 |
| 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**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 **No**: |
|  |  |  |

Proposals 1.A – 1.F are taken from the final outcome of the offline discussion [1]:

* Proposal 1.B: Instead of using the final version from the FL, the format proposed by Apple is used with some refinement (marked red)

The following observation can be made:

* ...

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:

* For the number of configured TCI states (including joint TCI state(s), DL-only TCI state(s), UL-only TCI state(s), and/or DL-only+UL-only TCI state(s)), the largest configurable value is 128
* For the number of codepoints in the TCI field for DCI-based beam indication (hence the number of codepoints activated via MAC-CE-based TCI state activation), the largest configurable value is 8

**Proposal 1.B:** On Rel.17 unified TCI framework, for Rel-17 unified TCI:

* For DL channels/signals that do 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), all the QCL rules defined in section 5.1.5 in 38.214 are supported
	+ Note: For CSI-RS used to provide QCL indication for non-UE dedicated channels, the CSI-RS should only be QCLed with SSB of the same PCID as that from the serving cell
* 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), only the following options on source RSs and QCL-Types are supported
	+ Option 1: TRS is configured for QCL-TypeA ~~indication~~ source RS and CSI-RS for BM is configured for QCL-TypeD ~~indication~~ source RS
	+ Option 2: TRS is configured for QCL-TypeA and QCL-TypeD ~~indication~~ source RS
	+ Note: For inter-cell beam management, SSB with PCID different from that from the serving cell can be used as a QCL Type-D source RS for CSI-RS for BM and/or TRS

[Tables may be added on source-target relation for better clarity, e.g.

*For joint TCI and DL-only TCI*

|  |  |
| --- | --- |
| **Source RS (\*)** | **Target RS** |
| SSB | Periodic TRS  |
| CSI-RS for BM |
| CSI-RS for CSI |
| Periodic TRS | AP TRS |
| CSI-RS for BM |
| CSI-RS for CSI |
| PDCCH/PDSCH DMRS |
| CSI-RS for BM | Periodic TRS |
| CSI-RS for BM  |
| CSI-RS for CSI  |
| PDCCH/PDSCH DMRS  |
| CSI-RS for CSI | PDCCH/PDSCH DMRS  |

*For UL-only TCI*

...

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**Proposal 1.C.1**: On Rel.17 unified TCI framework, remove the brackets and clarify as indicated in red from the following *previous 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:*

* *…*
* *Just as Rel.16, the source RS in the Rel-17 TCI state that provides QCL-TypeA ~~[or QCL-TypeB]~~ shall be in the same CC as the target channel or RS*
* *…*

**Proposal 1.C.2**: On Rel.17 unified TCI framework, the source RS in the Rel-17 TCI state that provides QCL-TypeA or QCL-TypeB shall be in the same CC as the target channel or RS

**Proposal 1.D**: On Rel.17 unified TCI framework, remove the brackets as indicated in red from the following *previous agreement*:

*For common TCI state ID update and activation to provide common QCL information at least for UE-dedicated PDCCH/PDSCH and/or common UL TX spatial filter(s) at least for UE-dedicated PUSCH/PUCCH across a set of ~~[~~configured~~]~~ CCs/BWPs:*

*...*

**Proposal 1.E**: On Rel.17 unified TCI framework, regarding the common TCI state ID update and activation for CA, the reference CC/BWP is the CC/BWP in which the common TCI state pool (list of TCI states) is configured.

* The details on how the PDSCH configuration (for each of those CCs/BWPs) contains a reference to the RRC-configured TCI state pool(s) in a reference BWP /CC are up to RAN2

**Proposal 1.F**: On path-loss measurement for Rel.17 unified TCI framework, a PL-RS (configured for path-loss calculation, already assumed periodic) is either a periodic CSI-RS or an SSB. When a periodic CSI-RS is used as a PL-RS, decide in RAN1#106bis-e between the two following options:

* Opt1. Only 1-port periodic CSI-RS is supported for PL-RS
* Opt2. Both 1- and 2-port periodic CSI-RS are supported for PL-RS

**Proposal 1.G**: On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, “beam alignment” also pertains to the following events:

* The PL-RS is identical to the QCL Type-D RS of UL TCI spatial relation RS
* The QCL Type-D RS of PL-RS is identical to the UL TCI spatial relation RS
* The QCL Type-D RS of PL-RS is identical to the QCL Type-D RS of UL TCI spatial relation RS

**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:

* The multiple settings are configured via RRC
* Optionally, the association between a TCI state and one of the multiple settings, for each of the PUSCH, PUCCH, and/or SRS, is signaled via MAC-CE together with the MAC-CE-based TCI state activation

Table 2 Additional inputs: issue 1

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 1****2) Share your inputs on the above FL proposals** |
| MediaTek | Proposal 1.A: Support Proposal 1.B: Support, but the following table may not be needed.Proposal 1.C.1: SupportProposal 1.C.2: SupportProposal 1.D: SupportProposal 1.E: SupportProposal 1.F: SupportProposal 1.G: Support the three cases as “beam alignment” if both PL-RS and spatial relation RS are not CSI-RS for BM. This is because if any one of PL-RS and spatial relation RS is CSI-RS for BM, it is possible that UE determines a beam different from the one determined from the corresponding QCL-TypeD source RS according to a BM procedure.**Proposal 1.G**: On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, “beam alignment” also pertains to the following events when both PL-RS and UL TCI spatial relation RS are not CSI-RS for BM:* The PL-RS is identical to the QCL Type-D RS of UL TCI spatial relation RS
* The QCL Type-D RS of PL-RS is identical to the UL TCI spatial relation RS
* The QCL Type-D RS of PL-RS is identical to the QCL Type-D RS of UL TCI spatial relation RS

Proposal 1.H: Support |
| NTT Docomo | Proposal 1.A: We prefer to increase the max number of configured TCI states.Proposal 1.B: **Question:** Is it correct understanding that the 1st bullet means DL channels/signals with Rel.15/16 TCI state and 2nd bullet means DL channels/signals with Rel.17 TCI state?Proposal 1.C.1: Support.Proposal 1.C.2: Support. It is consistent with Rel.15/16.Proposal 1.D: Support.Proposal 1.E: Support.Proposal 1.F: Support. We assume CSI-RS includes TRS. We think Opt.1 is straightforward.Proposal 1.G: Support.Proposal 1.H: **Question**: What does "Optionally" imply? Do we consider the case that multiple settings are configured but the association is not configured? |
| Qualcomm | For 1.A, suggest to add “if agreed” after the DL-only+UL-only TCI state. I think we haven’t agreed that each TCI state can serve as both DL-only and UL-only.* For the number of configured TCI states (including joint TCI state(s), DL-only TCI state(s), UL-only TCI state(s), and/or DL-only+UL-only TCI state(s) if agreed), the largest configurable value is 128

For 1.B-1.H, support |
| Samsung | **Proposal 1.A**: We prefer to increase both the number of activated TCI state codepoints to 16, and the number of RRC configured TCI states to 256.**Proposal 1.B**: Proposal 1.B has two parts; we are fine with the first part which covers DL channels/signals that share the TCI state of dedicated channels. However, we would like to clarify if this applies only to Type-D QCL relations or all QCL relation types. So far, we have only agree Type-D and Type-A QCL Types for the Rel-17 TCI state.We are fine with the second part dealing with UE dedicated DL channels and DL channels/signals that share the TCI state of UE dedicated DL channels.We prefer to keep the table to have all the details clearly spelled out and avoid any potential misunderstanding or ambiguity.**Proposal 1.C.1:** Support**Proposal 1.C.2:** Support**Proposal 1.D:** Support**Proposal 1.E:** Support**Proposal 1.F:** Support. On the decision to decide between option 1 and option 2, if option 2 is configured, it is up UE implementation to decide if one (which one) or both antenna ports are used for PL estimation.**Proposal 1.G:** Support. We suggest a small update to reflect the fact that the source RS of an UL TCI state can be an SRS, which doesn’t really have a QCL Type-D source RS, but rather a source spatial relation RS (that can be a DL RS)**Proposal 1.G**: On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, “beam alignment” also pertains to the following events:* The PL-RS is identical to the QCL Type-D RS or source spatial relation RS of UL TCI spatial relation RS
* The QCL Type-D RS of PL-RS is identical to the UL TCI spatial relation RS
* The QCL Type-D RS of PL-RS is identical to the QCL Type-D RS or source spatial relation RS of UL TCI spatial relation RS

**Proposal 1.H:** We prefer that multiple setting are configured by RRC (i.e. a list of settings) and then the association is done MAC CE. The case of no association by MAC CE is the case when there is one setting configured, hence there is no need to do association.We would like to clarify if the multiple settings configure by RRC are common for all channels or a different list of settings is used for each channel. |
| Ericsson | **Proposal 1.A:** OK. **Proposal 1.B:** we prefer to reuse the Rel16 QCL rules fully, and we do not see why there is a need to describe the common beam operation separately. The only rules that are applicable are those applicable for PDCCH/PDSCH DMRS, hence1. TRS+TRS
2. TRS+CSI-RS for BM
3. CSI-RS for CSI + CSI-RS for CSI

However, if there is a good reason to remove the third bullet, we can accept that.**Proposal 1.C.1**: Don’t support – the proposal is inconsistent. In Rel-16, the RS that provides QCL-TypeB must be in the same CC. Would this proposal mean that QCL-TypeB can be derived from an RS on another CC??**Proposal 1.C.2**: Support. **Proposal 1.D:** Don’t support, the meaning is unclear. The subbbullets describe the complete procedure, so it is unclear what an additional “configured” in the main bullet would mean.**Proposal 1.F:** Note that 2-port CSI-RS was discussed at length during the Rel-16 UE features, and the outcome was not really satisfactory. A potential support for 2-port CSI-RS will be subject to UE capability, and unless it is deemed really valuable, it would make sense to state that only 1-port CSI-RS is supported**Proposal 1.G:** We are ok, but it would seem late to introduce a term for discussion purposes. The specification impact of “beam misalignment” – whatever it means – is still unclear to us.**Proposal 1.H:** We should only use MAC CE for updates that are time-critical. Changing the TCI – to – PC parameter mapping does not qualify. As RAN1 as a whole has not identified that this is time-critical, it can be left to RAN2.  |
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### Issue 2 (inter-cell beam management)

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.1 | Offline conclusion 2.A (below)Note: The wording of proposal can be further refined (please describe in Table 4) | **Support**: Fujitsu**Not support**: MTK, NTT Docomo, Ericsson |
| 2.2 | Offline conclusion 2.B (below)Note: The wording of proposal can be further refined (please describe in Table 4) | **Support**:, Nokia/NSB, Spreadrum, MTK, LG, Qualcomm, Apple, MTK, Qualcomm, Samsung, Lenovo/MotM, OPPO, NEC, CATT, Sony, ZTE, Xiaomi, Huawei/HiSi, IDC**Not support**: Futurewei, Intel, NTT Docomo, Ericsson |
| 2.3 | For separate DL/UL TCI, need to add restriction that the indicated DL TCI and UL TCI are associated with SSBs of a same physical cell ID? | **Yes:** OPPO, Nokia/NSB, Samsung, Intel, Apple**No:** Ericsson, CMCC, Xiaomi, NTT Docomo, MTK, Qualcomm |
| 2.4 | Supported value(s) of NMAX (the maximum number of RRC configured PCIs different from the serving cell for measurement/reporting) * Alt1: NMAXis 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 measures up to X PCIs different from the serving cell PCI
	+ Additional restriction may be added by RAN4
* Alt2. NMAX=1
 | **Alt1:** Huawei/HiSi, Lenovo/MotM, Ericsson, CATT, CMCC, Samsung, Intel, NTT Docomo, MTK, Qualcomm**Alt2:** Spreadtrum, OPPO, Qualcomm |
| 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
 | **Alt1**: Huawei/HiSi, Xiaomi, Intel, Sony, LG, Samsung, Qualcomm (2nd preference)**Alt2**: ZTE, Lenovo/MotM, CATT, Xiaomi, NTT Docomo, Nokia/NSB, Apple, Qualcomm (1st preference), **Alt3**: OPPO, vivo, Ericsson, MTK |
| 2.6 | UCI design for L1-RSRP reporting: Reuse Rel-15 L1-RSRP table | **Yes:** Samsung, MTK, Qualcomm, Ericsson**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:** ZTE, Samsung, MTK, Qualcomm, Ericsson**No:**  |
|  |  |  |

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 represnets 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, 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), the supported number of physical cell IDs different from that of the serving cell will be decided as a part of UE feature discussion.

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

**Proposed conclusion 2.C**: On Rel-17 beam indication enhancements for inter-cell beam management, for separate DL/UL TCI, there is no consensus in restricting the indicated DL TCI and UL TCI to be associated with SSBs of a same physical cell ID.

**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 measures up to X PCIs different from the serving cell PCI
* Additional restriction may be added by RAN4

**Proposed conclusion 2.E**: On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP, there is no consensus in supporting event-driven inter-cell beam reporting

Table 4 Additional inputs: issue 2

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 3** **2) Share your inputs on the above FL proposals** |
| MediaTek | On Issue 2.1: This capability signaling is not needed since a similar UE capability already has been agreed for the same purpose. The only remaining issue is how to clarify the FFS part. The conclusion in Proposal 2.A may not be needed since the capability can be proposed in UE feature discussion.**Agreement from RAN#106**On Rel.17 beam indication enhancements for inter-cell beam management, 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):* Support a UE feature on how many physical cell IDs (including that of the serving cell) can be associated with the activated TCI states
	+ FFS: If UE is configured for only one physical cell ID, decide between the following two options:
		- Opt1: the NW can activate TCI states associated with either the same physical cell ID as that of the serving cell or a different physical cell ID from that of the serving cell
		- Opt2: the NW can only activate TCI states associated with the same physical cell ID as that of the serving cell

Note: The above does not necessarily mean that more than 1 physical cell ID that is not serving cell in RRCProposal 2.B~2.E: Support |
| NTT Docomo | 2.A: Not support. Agree with MediaTek.2.B: Not support. In L1/L2 inter cell mobility, the UE only receives PDSCH from one TRP at a time, and only one Rx chain is needed, irrespective of the time-of-arrival of the PDSCH. So, there is no need to require that all DL signals are received within the CP.2.C: Support.2.D: Support.2.E: Not support. We believe event based beam reporting is beneficial. At least 14 companies support it, and 4 companies are against it. We prefer to continue discussion. |
| Qualcomm | For 2.A, suggest to add the following clarification, because it has been agreed in both Alt1 and Alt2 in the following agreement that UE can only support 1 non-serving PCI for measurement. In this case, the max activated TCI # for non-serving PCI is 1. …, the supported number of physical cell IDs different from that of the serving cell will be decided as a part of UE feature discussion with candidate value at least including 1.**Agreement**On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, select NMAX(the maximum number of RRC configured PCIs different from the serving cell for measurement/reporting) from the following alternatives (to be decided in RAN1#106bis-e): * Alt1: NMAXis 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 measures up to X PCIs different from the serving cell PCI
	+ Additional restriction may be added by RAN4
* Alt2. NMAX=1

For 2.B, suggest to include SSB as well. All other signals having Rx timing difference < CP implies SSB must be in the CP as well. Also clarify the CP refers to active DL BWP’s SCS.…, the reception of signals ~~other than SSBs from TRPs with PCIs differen~~t from the non-serving cell compared to that for serving cell is within one CP length for the SCS of active DL BWP. For 2.C, supportFor 2.D, FineFor 2.E, do we have detailed discussion on this? Suggest to discuss in this meeting further.  |
| Samsung | **Conclusion 2.A:** Tend to agree with MTK and NTT Docomo, that this is covered by an earlier agreement. **Conclusion 2.B:** Support**Conclusion 2.C:** We think this conclusion can be worded differently:On Rel-17 beam indication enhancements for inter-cell beam management, for separate DL/UL TCI, there is no consensus in ~~restricting~~ allowing the indicated DL TCI and UL TCI to be associated with SSBs of a ~~same~~ different physical cell ID.More importantly, what does “no consensus” mean, that UL TCI state and DL TCI state “can be” or “are not allow to be” on cells with different PCIs. We think the default should be “not allowed”.**Proposal 2.D:** Support**Conclusion 2.E:** Support |
| Ericsson | **Conclusion 2.A**: Don’t support: if there is a need for RRC signalling, there is a need to define something before going into UE feature discussions. It would seem appropriate to reuse what is designed for inter-cell mTRP. **Conclusion 2.B**: This would seem to be within the RAN4 scope – we do not see the RAN1 specification impact.**Conclusion 2.C:** Our understanding is that the inter-cell beam indication will reuse what we have for intra-cell, i.e., that separate is allowed, potentially subject to UE capability.**Conclusion 2.E:** Support |
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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**Alt2**: vivo, Samsung, APT/FGI**Alt3**: ZTE, Sony |
| 3.2 | Whether to support different values of Y for different cases. If so, details | **Yes**: Samsung (multi-panel), Huawei/HiSi (multi-panel), MTK (panel-swicthing, inter-cell with time difference greater than CP)**No**: OPPO, Ericsson |
| 3.3 | 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),  |
| 3.4 | 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**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**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 |
|  |  |  |

The following observation can be made:

* 3.1: Alt1 represmets the super-majority view
* 3.2: ... (need more views)

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

**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.

Table 6 Additional inputs: issue 3

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 5****2) Share your inputs on the above FL proposals** |
| MediaTek | Support Proposal 3.A. We have concern on Alt2 and Alt3.* Concern on Alt2: May cause unnecessary latency compared with Alt1 when the CC carrying the ACK of the beam indication has the smallest SCS but it is not one of the CCs applying the new beam. This case can happen in FR1+FR2 CA where PUCCH cell is usually configured in FR1 with much smaller SCS compared with the CCs in FR2, thus larger additional latency.
* Concern on Alt3: Alt3 cannot guarantee that the switching timing always occurs at the slot boundary if the CC carrying the ACK of the beam indication has SCS larger than the SCS(s) of CC(s) applying the new beam.

On Issue 3.4: We see a potential issue may happen during the transition time between TCI activation and a DCI indicates a TCI state from the new activated TCI list. During the transition time, if the currently applied TCI state is not in the new activated TCI list, UE needs to track on one more TCI states (M TCI states in the list + 1 currently applied TCI state) before a DCI indicates a TCI state from the new activated TCI list. In order to avoid this, the activated TCI state(s) for the lowest codepoint is/are applied until a beam indication DCI is received when more than one TCI codepoints are activated by MAC CE and the currently applied TCI state(s) is not in the new active TCI list. |
| NTT Docomo | Proposal 3.A: Support. We think issue 3.2 can be discussed separately.On Issue 3.3, we don’t understand the discussion point. As the agreement below, indicated beam is updated after the acknowledgment (ACK). There is no agreement that Y-symbol is counted from ACK/NACK. So, “***only ACK can be used to confirm beam indication*”** is already agreed.**Agreement**On Rel-17 DCI-based beam indication, regarding application time of the beam indication, the first slot to apply the indicated TCI is at least Y symbols after the last symbol of the acknowledgment of the joint or separate DL/UL beam indication.* Note: The Y symbols are configured by the gNB based on UE capability, which is also reported in units of symbols.
* FFS whether Y is configured per BWP , per CC or per band or per SCS , or independent of BWP/CC/SCS
	+ Note: Previous agreement in RAN1#104b-e that remaining unused DCI fields and codepoints are reserved in R17 are not to be reverted

Issue 3.4: we think group common beam indication is beneficial to reduce DCI transmission to multiple UEs. Also, when MAC CE indicates multiple active TCI states, beam indication DCI can select one of the active TCI states. How to determine the QCL assumption of the beam indication DCI should be discussed (e.g. previous common beam, or the lowest TCI codepoint). |
| Qualcomm | For 3.A, support, this option requires the minimum application time, which is dynamically determined based on all applied SCSs. Considering ACK SCS may unnecessarily increase the application time.  |
| Samsung | **Proposal 3.A:** For progress we can accept as this is the majority view. But we would like to point out that the general principle since NR Rel-15 to determine latency has been to base this on the SCS of the channel carrying the indication as well as the channel to which the indication is being applied. For example, to determine the processing latency for HARQ-ACK feedback, this not only depends on the SCS of the HARQ-ACK feedback carrying channel, but also on the SCS of the corresponding PDCCH and PDSCH … this is an example from 38.214 (section 5.3):*N1* is based on *µ* of table 5.3-1 and table 5.3-2 for UE processing capability 1 and 2 respectively, where *µ* corresponds to the one of (*µPDCCH*, *µPDSCH*, *µUL*) resulting with the largest *Tproc,1*, where the *µPDCCH* corresponds to the subcarrier spacing of the PDCCH scheduling the PDSCH, the *µPDSCH* corresponds to the subcarrier spacing of the scheduled PDSCH, and *µUL* corresponds to the subcarrier spacing of the uplink channel with which the HARQ-ACK is to be transmitted, and κ is defined in subclause 4.1 of [4, TS 38.211].The rationale for this is when the UE is receiving/transmitting the channel triggering the processing (in this case the HARQ-ACK with positive feedback to trigger beam switching) its processing timing could be based on the SCS of that channel. Typically, the smaller SCS has the longer processing delay.**Issue 3.4:** While we were strongly supportive of some of the features mentioned in this category, unfortunately it is too late at this stage. We still have a number of pressing issues to resolve and issue 3.4 is not one of them. |
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### Issue 4 (MP-UE)

Table 7 Summary: issue 4

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| **#** | **Issue** | **Companies’ views** |
| 4.1 | Per RAN1#106-e agreement**Scheme 1**: a panel entity corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance (i.e. Opt1-1 per RAN1#104-bis-e agreement) ...vs**Scheme 2**: support UE reporting one of the following (to be down selected in RAN1#106bis-e): * **Opt1**. A list of supported UL ranks (number of UL transmission layers)
* **Opt2**. A list of supported number of SRS antenna ports
* **Opt3**. A list of coherence types (as in Rel-15) indicating a subset of ports
 | **Scheme 1 (18)**: Huawei/HiSi, IDC, Spreadtrum, vivo, Fujitsu, Lenovo/MotM, Fraunhofer IIS/HHI, NTT Docomo, Sony, AT&T, Apple, LG, Qualcomm, ZTE, [Xiaomi]**Scheme 2 (12)**: ZTE, Samsung, OPPO, CMCC, MTK, NTT Docomo, Nokia/NSB, [Ericsson, Intel, Apple], ZTE* **Opt1**: MTK, [Intel]
* **Opt2**: Nokia/NSB, OPPO
* **Opt3**: Samsung, OPPO

**Do not support scheme 1**: Ericsson, Nokia/NSB**Do not support Scheme 2**: CATT |
| 4.2 | Multiple SRS resource sets with different SRS #ports | **#SRS resource sets*** **2**: Samsung, OPPO, Fraunhofer IIS/HHI
* **3**: Samsung, Qualcomm

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

**#SRS ports in each set*** **1, 2, 4**: Samsung, Qualcomm
 |
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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,

* A panel entity corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance (i.e. Opt1-1 per RAN1#104-bis-e agreement)
	+ The correspondence between a panel entity and a reported CSI-RS and/or SSB resource index is informed to NW
		- FFS: Detailed design of how to inform the correspondence to NW
	+ Note: the correspondence between a CSI-RS and/or SSB resource index and a panel entity is determined by the UE (analogous to Rel-15/16)
* Support UE reporting of maximum number of SRS ports and coherence type for each panel entity as a UE capability
* Support multiple c odebook -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, where the SRS resource set should be aligned with the UE capability for the panel entity

Table 8 Additional inputs: issue 4

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 7** **2) Share your input on the above FL proposals** |
| MediaTek | We are fine with the Proposal 4.A. However, for coherence type for each panel entity, can anyone clarify the purpose and corresponding behavior after NW receives the capability report? According to the following agreement made in RAN1#102, UE panels having different coherence types were not considered in the Rel-17 MP-UE assumption.**Agreement from RAN1#102*** [Issue 4] For Rel.17 NR FeMIMO, on MP-UE assumption to facilitate fast UL panel selection:
	1. The following assumptions are used:
		+ In terms of RF functionality, a UE panel comprises a collection of TXRUs that is able to generate one analog beam (one beam may correspond to two antenna ports if dual-polarized array is used)
		+ UE panels can constitute the same as well as different number of antenna ports, number of beams, and EIRP
		+ No beam correspondence across different UE panels
		+ FFS: For each UE panel, it can comprise an independent unit of PC, FFT timing window, and/or TA
		+ FFS: Same or different sets of UE panels can be used for DL reception and UL transmission, respectively
 |
| Qualcomm | Support. We believe the panel entity is benefitial to provide a unified framework for all panel related features. The panel entity can be represented by existing ID, e.g. SRS resource set ID. |
| Samsung | In our view, the key question is the FFS on “how the correspondence between a panel entity and a reported CSI-RS and/or SSB resource index is informed to NW?”. Without resolving this FFS, this proposal may not be acceptable to proponents of scheme 2. Perhaps, one of Options in Scheme 2 can be included. We prefer Opt3 (coherence type), but can be open to other Options. So, we suggest:**Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection, * A panel entity corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance (i.e. Opt1-1 per RAN1#104-bis-e agreement)
	+ The correspondence between a panel entity and a reported CSI-RS and/or SSB resource index is informed to NW
		- ~~FFS: Detailed design of how to inform the correspondence to NW~~
		- The correspondence is based on at least one of Opt1-3 in scheme 2
	+ Note: the correspondence between a CSI-RS and/or SSB resource index and a panel entity is determined by the UE (analogous to Rel-15/16)
* Support UE reporting of maximum number of SRS ports and coherence type for each panel entity as a UE capability
* Support multiple c odebook -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, where the SRS resource set should be aligned with the UE capability for the panel entity

Re coherence type, the UE behavior is already defined in Rel.15 (6.1.1.1, 38.214)* 2Tx UE: full-coherent (2 port/layer), non-coherent (1 port/layer)

4Tx: full-coherent (4 ports/layer), partial-coherent (2 ports/layer), and non-coherent (1 port/layer) |
| Ericsson | **Proposal 4.A**: Do not support. Already in RAN1#106-e, it was clear that we and others had concerns on scheme 1, and those remain. Based on this, any discussion should start from scheme 2.  |
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### Issue 5 (MPE mitigation)

Table 9 Summary: issue 5

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| **#** | **Issue** | **Companies’ views** |
| 5.1 | Confirm working assumption on reporting M SSBRI(s)/CRI(s) together with N P-MPR(s) | **Yes**: ZTE, Samsung, CATT, CMCC, Xiaomi, Intel, NTT Docomo, Ericsson, Sony, Nokia/NSB, Apple, Qualcomm, LG**No**: vivo (include panel ID) |
| 5.2 | Supported value(s) of N and M | Supported value(s) of N:* **{1}**: Ericsson
* **#beams {1,2,3,4 + UE cap}** (same as Rel-15/16 beam reporting): ZTE, Samsung, Sony, Nokia/NSB, Qualcomm, MTK
* **Other** (specify):
	+ **#panels (2,3, or depends on UE cap)**: Spreadtrum, Lenovo/MotM, CATT, Xiaomi, LG

Supported value(s) of M:* **Only 1**: ZTE, Samsung, Ericsson, CATT, Intel, NTT Docomo, Sony, Nokia/NSB, Apple, LG, Qualcomm, MTK
* **Other** (specify):
	+ **M=#panels – N**: Spreadtrum
 |
| 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

Candidate resource pool:* **Configured via RRC**: CATT
* **Configured via RRC using CSI report config**: Samsung, [Nokia/NSB], MTK
 |
| 5.4 | Beam vs panel level | **Beam**: IDC, Sony, Nokia/NSB, Qualcomm, MTK**Panel**: Huawei/HiSi, Spreadtrum, vivo, Lenovo/MotM, CATT, LG**No need to discuss**: Ericsson |
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The following observation can be made:

* 5.1, 5.2: Confirming the WA represents the super-majority view
	+ M=1 represents the super-majority view
	+ At least N=1 can be agreed, while the need for N={2, 3, 4} requires more discussion (also dependent on the outcome of issue 4)

Based on the above observation, the following proposal can be made:

**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 at least N=1

* Discuss and decide in RAN1#106bis-e whether to support N=2, 3, and/or 4

Table 10 Additional inputs: issue 5

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 10** **2) Share your inputs on the above FL proposals** |
| MediaTek | Support both Proposal 5.A and Proposal 5.B |
| Qualcomm | For 5.A and 5.B, support |
| Samsung | Support Proposal 5.A and 5.B, perhaps, the wording “*up to*” can be deleted from 5.A.*For each P-MPR value, ~~up to~~ M SSBRI(s)/CRI(s)….* |
| Ericsson | Support  |
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### Issue 6 (advanced beam refinement/tracking)

Table 11 Summary: issue 6

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| **#** | **Issue** | **Companies’ views on specific candidate schemes** |
| 6.1 | UE-initiated beam management:* ALT1. UE -initiated (DL-only or DL/UL) beam selection, including the following options
	+ Opt1. The selected beam is reported by an event-triggered UE beam reporting via, e.g. UCI, MAC CE, UL CG, or Type 1/Type 2 CBRA/CFRA
	+ Opt2. The selected beam is reported by a legacy UE beam report (NW-configured)
	+ FFS on triggering condition and NW-indication of a beam group in which the UE is allowed to do the beam selection, e.g., the NW-indication via MAC-CE
	+ FFS: NW confirmation, e.g. if no NW beam selection command overwriting the selected beam is received in a time window after the report
* ALT2. UE-initiated beam activation based on beam reporting
	+ The reported beam(s) are activated as active TCI/spatial relation RS(s) automatically w/o NW activation command after receiving gNB response signalling, e.g. DCI/MAC CE
	+ FFS: The reported beam is applied directly if the number of supported activated beam by the UE is one and/or after receiving gNB response signaling, or if no NW activation command overwrites the beam(s) activated by the report in a time window after the report
* ALT3. UE -initiated UL-only beam selection considering potential misalignment between network and UE on the selected beams
	+ The UE can select an alternative beam from the other beams in the gNB -configured set containing more than one UL beam
 | **ALT1**: MTK (Opt2), NTT Docomo (Opt.1: MAC CE), Qualcomm (Opt2), Samsung (Opt 1)**ALT2**: MTK, NTT Docomo, Qualcomm, Samsung**ALT3**: Qualcomm, Samsung |
|  |  |  |

The following observation can be made:

* ...

Based on the above observation, the following proposal can be made:

**Proposal 6.A**: On Rel.17 enhancements to facilitate advanced beam refinement/tracking, [after more inputs/discussion]

Table 12 Additional inputs: issue 6

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 12**  |
| Samsung | We are supportive of ALT1 , ALT2, and ALT3. At the same time, we understand that we only have 2 meetings left for Rel-17. To ensure that we can still finish in time, it is better to focus on one aspect and leave the rest of ALT1 and ALT2 to Rel-18. If we are to choose one, we propose to focus on ALT1 Opt1 for Rel-17. |
| Ericsson | All the alternatives have huge unclarities and explicit large FFSs. Propose to postpose to Rel-18.  |
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# References

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | R1-2109467 | Summary of offline discussion on unified TCI and inter-cell beam management | Moderator (Samsung) |
| 2 | R1-2108756 | Enhancements on multi-beam operation in Rel-17 | Huawei, HiSilicon |
| 3 | R1-2108796 | Enhancement on multi-beam operation | FUTUREWEI |
| 4 | R1-2108808 | Further Discussion on Enhancements for Multi-beam Operation | InterDigital, Inc. |
| 5 | R1-2108870 | Enhancements on Multi-beam Operation | ZTE |
| 6 | R1-2108895 | Enhancements on Multi-beam Operation | Spreadtrum Communications |
| 7 | R1-2108951 | Further discussion on multi beam enhancement | vivo |
| 8 | R1-2109029 | Enhancements on Multi-beam Operation | Fujitsu |
| 9 | R1-2109038 | Enhancements on Multi-beam Operation | OPPO |
| 10 | R1-2109103 | Enhancements on Multi-beam Operation | Lenovo, Motorola Mobility |
| 11 | R1-2109110 | Remaining issues on multi-beam enhancements | Ericsson |
| 12 | R1-2109122 | Discussion on multi-beam operation | NEC |
| 12 | R1-2109180 | Enhancements on multi-beam operation | TCL Communication Ltd. |
| 14 | R1-2109184 | Futher discussion on Rel-17 multi-beam operation | CATT |
| 15 | R1-2109270 | Enhancements on multi-beam operation | CMCC |
| 16 | R1-2109350 | Enhancements on multi-beam operation | Fraunhofer IIS, Fraunhofer HHI |
| 17 | R1-2109378 | Enhancements on multi-beam operation | Xiaomi |
| 18 | R1-2109468 | Multi-Beam Enhancements | Samsung |
| 19 | R1-2109543 | Enhancement on multi-beam operation | MediaTek Inc. |
| 20 | R1-2109591 | Enhancements to Multi-Beam Operations | Intel Corporation |
| 21 | R1-2109658 | Discussion on multi-beam operation | NTT DOCOMO, INC. |
| 22 | R1-2109772 | Further enhancement on multi-beam operation | Sony |
| 23 | R1-2109832 | Discussion of enhancements on multi-beam operation | FGI, Asia Pacific Telecom |
| 24 | R1-2109870 | Enhancements on Multi-beam Operation | Nokia, Nokia Shanghai Bell |
| 25 | R1-2109923 | Enhancements on Multi-Beam Operations | AT&T |
| 26 | R1-2110013 | Views on Rel-17 Beam Management enhancement | Apple |
| 27 | R1-2110077 | Enhancements on Multi-beam Operation | LG Electronics |
| 28 | R1-2110103 | Enhancements on Multi-beam Operation | Convida Wireless |
| 29 | R1-2110165 | Enhancements on Multi-beam Operation | Qualcomm Incorporated |
| 30 | R1-2108877 | Further details on Multi-beam and Multi-TRP operation | ZTE |
| 31 | R1-2109045 | Discussion on further enhancements for multi-beam operation | OPPO |
| 32 | R1-2109475 | Additional enhancements for multi-beam | Samsung |
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