**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 |

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, Convida, Futurewei, Xiaomi, AT&T. NEC, Huawei, HiSilicon * **No (increase to 16):** Samsung   **Max total 128 configured TCI states (same as Rel.15/16):**   * **Support (13):** vivo, Lenovo/MotM, CMCC, Nokia/NSB, OPPO, MTK, Fujitsu, Qualcomm, IDC, Spreadtrum, Futurewei, NEC * **No (increase to 256) (10):** ZTE, Ericsson, Samsung, APT/FGI, LG, Intel, NTT Docomo, Convida, AT&T |
| 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, Nokia/NSB, Xiaomi, NEC  **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, Convida, Nokia/NSB, Futurewei, Xiaomi, NEC, Sony, Huawei, HiSilicon * **Not support**:   **1.C.2:**   * **Support**: MTK, Samsung, ZTE, Intel, vivo, CMCC, Fujitsu, Qualcomm, Ericsson, Convida, Nokia/NSB, Futurewei, NEC * **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, Futurewei, Xiaomi, NEC, Huawei, HiSilicon  **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, Convida, Nokia/NSB, Futurewei, IDC, Xiaomi, AT&T, NEC  **Not support**: Huawei, HiSilicon |
| 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, Nokia/NSB, Futurewei, Xiaomi, AT&T, NEC, Huawei, HiSilicon  **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, Futurewei, AT&T, NEC, Huawei, HiSilicon  **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, Futurewei, Huawei, HiSilicon  **Not support (RRC only)**: vivo, Intel, Ericsson, Spreadtrum |
| 1.9 | For separate TCI, UL TCI state pool  Alt1: Shared pool with joint/DL TCI state  Alt2: 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 (11)**: CMCC, Ericsson, Futurewei, Huawei/HiSi, Fraunhofer IIS/HHI, IDC, Sony, Apple, AT&T |
| 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  Note: CSI-RS for tracking (TRS) and CSI-RS for BM have been agreed  Note: 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 (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**: |
|  |  |  |

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)

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), and/or 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
  + Further discuss and decide in RAN1#106bis-e whether CSI-RS for CSI can be used as a source RS or not, and if so whether some restriction(s) are needed

[To be further discussed: whether 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*

...

]

**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 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
* Note: It has been agreed that the reference CC/BWP is the CC/BWP in which the common TCI state pool (list of TCI states) is configured.

**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, when both PL-RS and UL TCI spatial relation RS are not CSI-RS for BM, “beam alignment” also pertains to the following events:

* The PL-RS is identical to the QCL Type-D or UL 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 or UL spatial relation 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 (when a TCI state can be associated with at least two of the RRC-configured multiple settings), the association between a TCI state and one of such 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

|  |  |
| --- | --- |
| **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: Support  Proposal 1.C.2: Support  Proposal 1.D: Support  Proposal 1.E: Support  Proposal 1.F: Support  Proposal 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.  [Mod: I see your point.]  **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?  [Mod: No. In the 1st bullet, Rel-17 TCI states are used. But those channels/signals do not share the same TCI state as that for UE-dedicated PDCCH/PDSCH]  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?  [Mod: Huawei commented in OFFLINE that the agreement says that the association “can” be configured (hence it is optional). But the wording ‘optionally’ can be better refined to avoid confusion (please see revision)] |
| 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   [Mod: Good point. We only agreed that the two can be indicated together. Removed. Thanks for pointing it out.]  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.  [Mod: The proposal includes all rules in 5.1.5 hence extends beyond Type-D (indeed a superset of the previous agreement)]  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   [Mod: Correct. Done]  **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.  [Mod: Good point. Done] |
| 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, hence   1. 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.  [Mod: In OFFLINE, Apple has mentioned a potential complication for aperiodic CSI-RS for CSI (when scheduling offset < threshold). I added a bullet so we can further discuss this issue without stopping the possible progress]  **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??  [Mod: Please check OFFLINE. The concern with removing the brackets voiced by most companies is that QCL Type-B cannot apply for PDSCH/PDCCH which is the context of the common indication for CA. Therefore, MTK proposed to remove QCL Type-B here and added proposal 1.C.2 (wider context).]  **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.  [Mod: As mentioned OFFLINE, it simply follows the other CA agreement in RAN1#105-e where ‘configured’ is used.]  **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  [Mod: We will finalize this in the next round]  **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.  [Mod: Yes. It is perhaps something we notify RAN4 – although strictly speaking it is unclear if RAN4 will do anything about this either.]  **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.  [Mod: From FL perspective I fully agree. But it seems the overwhelming majority prefers this :☹] |
| ZTE | **Proposal 1.A:** We suggest to increase the number of configured TCI states from 128 to 256. The increase of configured TCI states has already identified in the WID:   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:   [Mod: Unfortunately, a plain reading doesn’t suggest that increasing the maximum number of configured TCI states is a part of the WID. It simply says that “a larger number” is a use case (notice the absence of “maximum”). While the FL also prefers to increase to 256, I see slight majority wanting to keep it to 256]  **Proposal 1.B:** We are okay for clarifying the source-target relation. For DL, we need to consider QCL TypeA and QCL TypeD together, e.g.,  *For joint TCI and DL-only TCI*   |  |  |  | | --- | --- | --- | | **Source RS (QCL-TypeA)** | **Source RS (QCL-TypeD)** | **Target RS** | | TRS | CSI-RS for BM | PDCCH DMRS | | PDSCH DMRS | | Aperiodic CSI-RS for CSI | | Aperiodic CSI-RS for BM | | TRS | TRS | PDCCH DMRS | | PDSCH DMRS | | Aperiodic CSI-RS for CSI | | Aperiodic CSI-RS for BM |   [Mod: Thank you. I will keep this for the next round. If companies agree to list all combinations in a table as a next step, we can do so after proposal 1.B is agreed.]  For UL-TCI, the controversial part is whether to reuse the R15/16 terminology, i.e., spatial relation, or QCL-TypeD. According to QCL definition (inferring channel quality from UE side), using QCL-TypeD may NOT be appropriate herein.  [Mod: Correct. For UL TCI we already have a clear agreement on UL spatial relation. Since there are no different types A/B/C/D for UL, a proposal similar to 1.B is not needed. For inter-cell, it has also been agreed that “non-serving SSB” can be used as an indirect reference for UL TCI. I agree with you.]  **Proposal 1.C.1/2:** Support.  **Proposal 1.E:** Support in principle, but how to handle multi-CC simultaneous MAC-CE/DCI base TCI activation/indication is still unclear. As in Rel-16, an explicit CC-list is configured for achieving the similar functionality.  [Mod: This can be discussed next round(s) although I am not sure what’s missing]  Then, for saving RRC overhead of PL-RS configuration, the reference mechanism can be further introduced for PL-RS configuration in our views.  **Proposal 1.E:** This issue has been discussed in Rel-16 UE capability discussion. The outcome should be Opt2 with UE capability.   |  |  |  | | --- | --- | --- | | 16-1j-2 | 2 port CSI -RS for pathloss estimation | Support of 2 port CSI -RS for  pathloss estimation  with the same resource counting as in FG 16-1g, FG 16-1g-1 |   [Mod: Opt1 proposes to simplify further. As the proposal says this is to be decided in the next round]  **Proposal 1.G:** Not support.In our views, we prefer to simplify the definition of beam alignment. In general, based on QCL definition, the gNB/UE still can use different Tx/Rx beams for PL-RS and target channels/RSs applied by TCI state under the following two cases (like beam change/refinement). Therefore, we do not identify the necessity of further introducing above two cases into the events of ‘beam alignment’ which can be considered as in ‘beam misalignment’.   * 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. The main motivation of MAC-CE based association is to handle beam-specific closed loop procedure. If the association is totally RRC preconfigured, we only have up to 2 closed loops, and then RRC based beam-specific closed loop procedure may not work well for dynamic beam switching. |
| Convida | OK with all proposals. For **Proposal 1.A,** we support to increase the max number of configured TCI states to 256. |
| FGI/APT | **Proposal 1.A:** We support the second bullet. Regarding the first bullet, we prefer to increase the number to 256. Perhaps we can agree the second bullet first, since the second bullet seems to gain super majority support.  [Mod: I agree, will do so – 1st bullet may need more discussion]  **Proposal 1.B to F:** We are OK with them. |
| Nokia/NSB | Proposal 1.A: Support  Proposal 1.B: Support  Proposal 1.C.1: Support  Proposal 1.C.2: Support  Proposal 1.D: Support  Proposal 1.E: Support  Proposal 1.F: Support  Proposal 1.G: Support  Proposal 1.H: Support  1.12: Our understanding that this would be the case already based on Rel15 in case of implicit determination of BFD RS.  [Mod: Good point, I agree. We will discuss more and finalize in the next round] |
| Futurewei | Proposal 1.A: Support in principle. As commented by Qualcomm, the meaning of “DL-only+UL-only TCI state(s)” needs to be clarified, or this term should be deleted.  [Mod: Agree. That’s a mistake from my part (confusion with indication), removed]  Proposal 1.B: On the second sub-bullet, further discussions are needed on whether CSI-RS for CSI can be configured to be the QCL-TypeA and QCL-TypeD source RS. Also need to clarify that the table is for QCL-TypeD source-target relation.  [Mod: We can discuss more re CSI-RS for CSI – see revision]  Proposal 1.C.1: Support.  Proposal 1.C.2: Support.  Proposal 1.D: Support.  Proposal 1.E: Support.  Proposal 1.F: Support.  Proposal 1.G: Support.  Proposal 1.H: Support. |
| Intel | **Proposal 1.A:** We want to clarify if there is any restriction on configuration of Rel-17 and Rel-15/16 TCI states in a CC. We are ok with the current limit of 128 if only one of Rel-17 TCI framework or Rel-15/16 TCI framework is allowed to be configured in a CC. If both are configured, we may need to increase limits to 256.  [Mod: I don’t think this mixture is a good NW implementation – also not good for UEs. I am not sure however if this needs to be factored in the current discussion.]  **Proposal 1.B:** Final version from FL summary was a better starting point. The tables should be kept in the proposal to avoid ambiguity. Additionally, based on working assumption from last meeting, the first main bullet implies Rel-15/16 TCI state which makes the statement in the first bullet obvious. So we may not need to agree on it.  [Mod: No. The first main bullet implies Rel-17 TCI states for the channels/signals not sharing the Rel-17 TCI state of UE-dedicated PDCCH/PDSCH:  On Rel.17 unified TCI framework,   * Any DL RS that is a valid target DL RS of a Rel-15/16 TCI state based on the Rel-15/16 QCL rules can be configured as a target DL RS of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool)   + Note: This does not imply that all such DL RSs necessarily share a same TCI state   + The DL RS includes CSI-RS and DMRS for PDSCH or PDCCH   ...  On Rel.17 unified TCI framework, for any DL RS that does not share the same indicated Rel-17 TCI state(s) as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC, but can be configured as a target DL RS of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool), Rel-17 mechanism(s) which reuse the Rel-15/16 TCI state update signaling/configuration design(s) are used to update/configure such DL RS(s) with Rel-17 TCI state(s).   * Applies for both intra-cell and inter-cell beam indication   ]  **Proposal 1.C.1:** Why is QCL Type B removed? In Rel-15/16 the same restriction (of being in the same CC) applies to both QCL-Type D and B. QCL Type B should be added back here  [Mod: Check OFFLINE and my above comments to Ericsson]  **Proposal 1.C.2:** OK  **Proposal 1.D/1.E:** OK  **Proposal 1.F:** Ok with Option 2  **Proposal 1.G:** OK  **Proposal 1.H:** Do not support. We do not see any need for MAC-CE based update of these relations. RRC alone is sufficient. |
| Apple | **Proposal 1.A:** In our view, it is better to discuss the total number of each type of TCI states instead discussing the total number for all types of TCI. 128 is not the same as Rel-16, since only up to 64 spatial relation can be supported for UL.  [Mod: This makes sense only for separate DL/UL TCI. But we can try – this issue seems to require more discussion in the next round(s)]  For number of active TCI codepoints, we suggest we reserve one TCI codepoint to indicate “no beam change”, since currently all DCI is the beam indication DCI, and this can help to resolve ambiguity when MAC CE re-actives the active TCI states.  [Mod: We can discuss this proposal in the next round(s)]  **Proposal 1.B:** OK with the proposal, but we think the table is not needed, since the proposal already mentioned all QCL rules in current spec, there should be no ambiguity. Besides, the table seems to be incomplete, as it looks to only capture QCL-TypeD.  [Mod: Whether tables are needed for clarity can be discussed in the next round(s)]  **Proposal 1.C.1:** This proposal seems to be unnecessary if we have proposal 1.B, but we are ok for the proposal.  **Proposal 1.C.2:** This proposal seems to be unnecessary if we have proposal 1.B, but we are ok for the proposal.  **Proposal 1.D:** We do not think the CCs/BWPs need to be configured. This is different from Rel-16 CC list based TCI indication, but it is related to TCI state pool sharing. At least for a band, gNB can share the TCI state pool. We also recommend to send an LS to RAN4 to ask their status on IBM/CBM on beam management for inter-band CA. in several previous agreements, we mentioned something like at least for intra-band CA, we may need to consider the inter-band CA issue. Since there are few meetings left, it may be the right time to think about inter-band CA.  **Proposal 1.E:** We are ok to leave it to RAN2, but before that we may need to conclude the inter-band CA issue first. Suggest an LS to RAN4 and CC RAN2.  [Mod: From RAN1 spec perspective, I am not sure how intra/inter-band is relevant. I think this was discussed before. But feel free to propose something for the next round(s)]  **Proposal 1.F:** Based on Rel-16 discussion, 2-port CSI-RS is not used. It is good to consider 1-port CSI-RS only. In addition, for 1-port CSI-RS, we suggest we clarify only density = 1 or 3 REs/RB is considered.  [Mod: Will finalize next round(s)]  **Proposal 1.G**: OK  **Proposal 1.H**: As we mentioned multiple times, currently the OL-PC parameters can be indicated by DCI in URLLC design. Thus, MAC CE is not needed, and one TCI should be associated with multiple OL-PC parameter sets.  [Mod: Check my comment for Ericsson] |
| OPPO | **Proposal 1.A:** Support  Proposal 1.B: Support.  **Proposal 1.C.1: Support**  **Proposal 1.C.2:** do not support. This proposal is not needed because QCL-TypeD is not applicable to PDCCH/PDSCH**.**  [Mod: I assume you mean ‘QCL Type-B’? Check my comment to Ericsson and OFFLINE discussion]    **Proposal 1.D:** Support  Proposal 1.E: Ok to leave the reference BWP/CC to RAN2. However, we do not think we need to define the reference BWP/CC again here. Because the “reference BWP/CC” was already clearly defined in previous agreement. We only need to conclude that the details on that is up to RAN2.  **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   [Mod: I agree. That part has been made a note]  Proposal 1.F: Support  Proposal 1.G: Do not support the current wording because some cases are missed. When the PL-RS is = to the QCL-TypeD RS of the UL filter, or when the QCL-TypeD RS of PL-RS and QCL-TypeD RS of UL filter are QCLed to the same TypeD source, it is also “beam alignment”. Therefore, we shall include these cases in the proposal as follows:  **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 * The PL-RS is identical to the QCL TypeD RS of UL TCI spatial relation RS. * The QCL Type-D RS of PL-RS and the QCL TypeD RS of UL TCI spatial relation RS are QCLed to the sane QCL Type-D RS source.   [Mod: The 1st red bullet is identical to the 1st black bullet ☺ The 2nd red bullet is semantically and functionally equivalent to the 2nd and 3rd bullets. I am not sure what other cases you have in mind that aren’t covered. But please check the latest version which I think should address your concern (per Samsung’s comment ‘UL spatial relation RS’ was missing – note that QCL doesn’t apply to UL)]  On the other hand, instead of listing all the possible cases, it is preferred to simply the description to avoid exhaustive listing. Except the first sub-bullet in the proposal, all the other sub-bullets actually intend to say that when the PL-RS and UL filter RS are QCLed with respect to the QCL-TypeD. Therefore, we suggest another version for the proposal:  **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 or the PL-RS and UL TCI spatial relation RS are QCLed with respect to QCL-TypeD. * ~~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~~   [Mod: See above] |
| Mod V14 | Revised proposals |
| Xiaomi | Proposal 1.A: Support the second bullet. While for the first bullet, since configuration of joint TCI or separate DL/UL TCI is based on RRC signaling, we think it means that if configured with joint TCI, the maximum number of joint TCI state(s) is 128. If configured with separate DL/UL TCI, the maximum number of the sum of DL-only TCI state(s) and UL-only TCI state(s) is 128. And we agree the case of configured with joint TCI state(s). While for separate, we think more TCI state(s) are needed if SSB/SRS is the QCL-TypeD source in UL-only TCI state.  Proposal 1.B: Support  Proposal 1.C.1: Support  Proposal 1.C.2: For QCL-TypeB, which is only configured to CSI-RS for CSI. We are confused whether it can be a unified TCI state or not.  Proposal 1.D: Support  Proposal 1.E: Support  Proposal 1.F: Support |
| vivo | **Proposal 1.A:** support  **Proposal 1.B:** agree with MediaTek and Apple, support this proposal but the table is not needed.  **Proposal 1.C.1:** support  **Proposal 1.C.2:** support  **Proposal 1.D:** support  **Proposal 1.E**: support in principle, but the number of reference CC/BWP needs to be clarified. For configuration in CA case, multiple CC lists are allowed to be configured, similar to Rel-16 higher layer parameters *simultaneousTCI-UpdateList1* and *simultaneousTCI-UpdateList2*. However, only one reference CC is in a configured CC list.  **Proposal 1.E**: On Rel.17 unified TCI framework, regarding the common TCI state ID update and activation for CA,   * 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 * Note: It has been agreed that the reference CC/BWP is the CC/BWP in which the common TCI state pool (list of TCI states) is configured. * Note: there is only one reference CC/BWP in a set of configured CCs/BWPs, where the reference CC/BWP is configured with common TCI state pool.   **Proposal 1.F**: support  **Proposal 1.G**: not support. As pointed by ZTE, it is not necessary to define a too complicated rule for beam alignment if the PLRS and the spatial relation RS in the UL or (if applicable) joint TCI state are not identical. These cases can be discussed in UE feature and considered as beam misalignment.  **Proposal 1.H**: not support. This is over-design. 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 May meeting discussion 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.  **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 and association with TCI states are configured via RRC |
| LG | Proposal 1.A: We prefer to support increasing the max number of configured TCI states to 256 for utilizing the same level of flexibility as legacy.  Proposal 1.G: Regarding the updated proposal, one case is still missing that when an SRS resource is used as UL TCI spatial relation RS, another BM SRS resource can be configured as spatial relation of the SRS resource. Since BM SRS may not have any spatial relation, it would be needed to use its PL-RS as the common PL-RS. Suggest to add the red part as below:  **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 CSI-RS for BM, “beam alignment” also pertains to the following events:   * The PL-RS is identical to the QCL Type-D or UL 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 or UL spatial relation RS of UL 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 |
| Fraunhofer IIS/HHI | **Proposal 1.A, 1.B, 1.C.1, 1.C.2, 1.D, 1.E:** Support  **Proposal 1.F:** Support. Opt2 with UE capability for 2-port seems a reasonable way forward  **Proposal 1.G:** Support the proposal with minor correction in first and third subbullet. The term 'UL spatial relation RS' in the first sub-bullet may mean that the PL RS is an UL RS and in the third bullet, it may mean that QCL typeD-RS of a DL RS (the PL-RS) is an UL RS, both of which are not possible. Therefore, remove the 'UL' before the spatial relation RS in the first and third sub-bullet to avoid misunderstanding.   * The PL-RS is identical to the QCL Type-D or ~~UL~~ 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 or ~~UL~~ spatial relation RS of UL TCI spatial relation RS |
| InterDigital | Proposal 1.A: Support  Proposal 1.C.1: Support  Proposal 1.C.2: Support  Proposal 1.D: Support  Proposal 1.E: Okay with the details up to RAN2  Proposal 1.F: Support  Proposal 1.G: Okay at least for discussion purposes |
| AT&T | Added more views in the table  Proposals 1.A: ok. Also support increasing max number of configured TCI states to 256  Proposal 1.B: support. We also think table is useful  Proposal 1.C, 1.E, 1.F, 1.G: support |
| Samsung | **Proposal 1.B:** As the proposal extends to all QCL Types, we suggest to update the table to include QCL Types as follows:   |  |  |  | | --- | --- | --- | | Source RS | Target RS | QCL Type(s) | | SSB | Periodic TRS | C+D or C | | CSI-RS for BM | C+D or C | | CSI-RS for CSI | A+D or A | | Periodic TRS | AP TRS | A+D or A | | CSI-RS for BM | A+D or A | | CSI-RS for CSI | A+D or A or B | | PDCCH/PDSCH DMRS | A+D or A | | CSI-RS for BM | Periodic TRS | D | | CSI-RS for BM | D | | CSI-RS for CSI | D | | PDCCH/PDSCH DMRS | D | | CSI-RS for CSI | PDCCH/PDSCH DMRS | A+D |   **Proposal 1.G:** We suggest the following update.   * This agreement covers the case of different CSI-RS for BM being used for PL-RS and spatial relation RS of UL TCI state. * The spatial relation RS of UL TCI state spatial relation RS can be an UL RS or a DL RS. * This also cover joint TCI states which can be used for UL beam indication (along with DL beam indication)   **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 ~~UL~~ spatial relation RS of UL or joint TCI spatial relation RS * The QCL Type-D RS of PL-RS is identical to the UL or joint TCI spatial relation RS * The QCL Type-D RS of PL-RS is identical to the QCL Type-D or ~~UL~~ spatial relation RS of UL or joint TCI spatial relation RS   **Proposal 1.H:** Our understanding of the proposal is that RRC configures a list (multiple settings) of PC settings. MAC CE associates PC setting (when multiple settings are configured in the list) to an activated TCI state. Therefore, we suggest the following update:  **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~~ A list of settings ~~are~~ is configured via RRC * Optionally (when the list of settings includes ~~a TCI state can be associated with~~ at least two ~~of the~~ RRC-configured ~~multiple~~ settings), the association between a TCI state and one of such ~~multiple~~ settings from the list, for each of the PUSCH, PUCCH, and/or SRS, is signaled via MAC-CE together with the MAC-CE-based TCI state activation |
| Qualcomm | For 1.H, should the TCI be associated with at least one of multiple settings, instead of two? If the multiple settings are clarified as for the same channel, I think it should be associated with at least one setting, instead of two.  **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, for each of the PUSCH, PUCCH, and/or SRS, are configured via RRC * Optionally (when a TCI state can be associated with at least one ~~two~~ of the RRC-configured multiple settings), the association between a TCI state and one of such 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 |
| NEC | Support the proposals and our preference has also been added in the table. More specifically,  Proposal 1C. 2: We may need to add BWP also into consideration since unified TCI framework can be configured/applied per BWP per CC. We suggestion the following modification:   * 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 BWP/CC as the target channel or RS   Support1.11 and 1.12, in case of explicit BFD RS configuration, we think it should be discussed. And in case of implicit BFD RS configuration, it seems Rel-15 scheme can be naturally reused, while beam failure recovery procedure should be updated (38.321), for example, in case of common beam changed based on DCI, beam failure recovery procedure should also be restarted, similar with “any of the reference signals used for beam failure detection is reconfigured by upper layers” in Rel-15. While this can be informed to RAN2 and updated by them. |
| Spreadtrum | **Proposal 1.A**: Support  **Proposal 1.B:** Support. We prefer to keep the table to avoid potential misunderstanding.  **Proposal 1.C.1**: Support  **Proposal 1.C.2**: Support  **Proposal 1.D:** Support.  **Proposal 1.E:** Support in principle. Similar view as vivo, we only need to configure one CC/BWP to be the reference for a set of CCs/BWPs.  **Proposal 1.F:** Support. Opt1 is preferred.  **Proposal 1.H:** Not support. In our understanding, MAC CE based association between TCI state and PC parameters may provide the flexibility to change the association for each channel/RS during each TCI state activation procedure. However, we do not see the need/advantage to do so. RRC based association should be enough. |
| TCL | **Proposal 1.A**: Support to increase the number of configured TCI states to 256 because the max number of configured TCI states of PDSCH and PDCCH plus configured spatial relations of PUCCH is already 256 in Rel-16.  **Proposal 1.B**: Support  **Proposal 1.D**: Support  **Proposal 1.E**: Support  **Proposal 1.F**: Support Opt1.  **Proposal 1.G**: Do not support. Agree with ZTE’s view |
| Sony | **Proposal 1.A**:  We are fine to keep the maximum number of configured TCI states and maximum number of TCI state codepoints as Rel.15/16.  Just in case that if RAN1 agrees 256 as maximum number of configured TCI states, it seems 16 TCI state codepoints should be supported accordingly. Otherwise, 8 TCI states codepoints would be the bottleneck of more TCI states configured.  One more comment similar as Intel is that we may need to state the upper bound of configurable TCI state more clearly as   * For the number of configured TCI states (including joint TCI state(s), DL-only TCI state(s), and/or UL-only TCI state(s)), the largest configurable value is 128 per Rel.17 TCI state pool   **Proposal 1.B**:  For DL channel/signal (whether it can share the same indicated TCI state of UE-dedicated PDCCH/PDSCH or not), we think it would be the simplest way to reuse the same and legacy QCL rule.  We can live with the FL proposal. One slight wording change to keep the door open for CSI-RS for CSI is as below   * 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), at least the following options on source RSs and QCL-Types are supported   **Proposal 1.D**: support.  **Proposal 1.E**: support.  **Proposal 1.G**:  The same view as Ericsson that we don’t clearly know the RAN1 impact of beam alignment (for discussion purpose only) and it seems too late to handover such complicated definition of beam alignment to other WG(s).  Speaking of the complexity, the QCL chain can be further dug as “The QCL Type-D RS (Level-3) of the QCL Type-D RS (Level-2) of PL-RS (Level-1)” |
| Huawei, HiSilicon | Added our preferences to table above.  Proposal 1.B: We prefer to keep the table of supported QCL rules or spatial relations, as they are the ones that will be captured in specs. Also, we suggest removing “only” from the 2nd bullet, as CSI-RS for CSI is still to be clarified (it has been agreed according to previous agreement).  Proposal 1.E: We did not notice an agreement indicating that “the reference CC/BWP is the CC/BWP in which the common TCI state pool (list of TCI states) is configured”, please clarify. Also, instead of “common TCI state pool”, we suggest changing it to “reference TCI state pool”. |
| Ericsson | Proposal 1.A: OK  Proposal 1.B: OK, agree with HW to remove ‘only’ in the 2nd bullet  Proposal 1.C.1: Support  Proposal 1.C.2: Support  Proposal 1.D: Can we clarify what it would imply? If it is only a header, without any functional impact, then there is no harm in adding it. On the other hand, there is no point in adding it either, since it does not change any functionality. To clarify, could we write  **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, where the configuration if performed as follows:*  Proposal 1.E: We are OK with the proposal, since the previous agreements specifies what a reference CC is.  Proposal 1.F, 1.G: OK  Proposal 1.H: Do not support. This is additional functionality, and it is completely unnecessary in our view. We want to leave as much as possible of the signalling design to RAN2, and this restricts the freedom without any benefit. |
| MediaTek | Proposal 1.E: We also think the previous agreement already implies the reference CC/BWP is the CC/BWP in which the common TCI state pool (list of TCI states) is configured. We are also fine with the clarification adding by vivo.  **Agreement**  On Rel.17 unified TCI framework, confirm the following working assumption as an agreement with a minor refinement highlighted in red  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:   * … * RRC-configured TCI state pool(s) can be absent in the PDSCH configuration (*PDSCH-Config*) for each BWP/CC, and replaced with a reference to RRC-configured TCI state pool(s) in a reference BWP/CC   + In the PDSCH configuration (*PDSCH-Config*) of the reference BWP/CC, RRC-configured TCI state pool(s) shall be configured   + For a BWP/CC where the PDSCH configuration contains a reference to the RRC-configured TCI state pool(s) in a reference BWP/CC, the UE applies the RRC-configured TCI state pool(s) in the reference BWP/CC   Proposal 1.G: We share the same view with Fraunhofer, and prefer the following update:  **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 CSI-RS for BM, “beam alignment” also pertains to the following events:   * The PL-RS is identical to the QCL Type-D or ~~UL~~ spatial relation RS of UL or joint TCI spatial relation RS * The QCL Type-D RS of PL-RS is identical to the UL or joint TCI spatial relation RS * The QCL Type-D RS of PL-RS is identical to the QCL Type-D or ~~UL~~ spatial relation RS of UL or joint TCI spatial relation RS   We see it is good to point out which cases can be considered as “beam alignment”, and the possible spec impact would be UE only expects these cases of NW configurations if UE doesn't support “beam misalignment”.  Proposal 1.H: We are fine with QC’s update.  We would like to add one important issue. According to current agreements for Rel-17 unified TCI framework, the following RSs “can share”, i.e., optionally, the same indicated Rel-17 TCI state as UE-dedicated data and control channels. However, how to differentiate whether a target RS should apply the same indicated Rel-17 TCI state or not is still a pending issue.   * SRS resource set for CSI (including CB, NCB, antenna switching) * Aperiodic CSI-RS resources for CSI * Aperiodic CSI-RS resources for BM * Aperiodic SRS resources or resource sets for BM * DMRS(s) associated with non-UE-dedicated reception on CORESET(s) and the associated PDSCH   **Issue 1.13: How UE differentiate/ NW configure the following DL channels/signals share (or 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)**   * **Aperiodic CSI-RS resources for CSI** * **Aperiodic CSI-RS resources for BM** * **DMRS(s) associated with non-UE-dedicated reception on CORESET(s) and the associated PDSCH**   **Issue 1.14: How UE differentiate/ NW configure the following UL channels/signals share (or not share) the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources (via Rel-17 MAC-CE/DCI TCI state update)**   * **SRS resource set for CSI (including CB, NCB, antenna switching)** * **Aperiodic SRS resources or resource sets for BM** |

### Issue 2 (inter-cell beam management)

Table 3 Summary: issue 2

|  |  |  |
| --- | --- | --- |
| **#** | **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, Spreadtrum |
| 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, ZTE, FGI/APT, Futurewei, NEC, Spreadtrum |
| 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, ZTE, FGI/APT, Futurewei, AT&T  **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 (9)**: Huawei/HiSi, Xiaomi, Intel, Sony, LG, Samsung, Qualcomm (2nd preference), Futurewei  **Alt2 (11)**: ZTE, Lenovo/MotM, CATT, Xiaomi, NTT Docomo, Nokia/NSB, Apple, Qualcomm (1st preference), Convida  **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  **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) |
| 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, Ericsson  Alt-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, 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.

* Decided 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.

**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 is RRC-configured for L1-RSRP measurement with up to X PCIs different from the serving cell PCI
* When more than one PCIs different from the serving cell PCI are configured in RRC, the UE is expected to be triggered or activated to measure more than one PCIs different from the serving cell PCI simultaneously
* 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

|  |  |
| --- | --- |
| **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 RRC  [Mod: Please check Apple’s comment in OFFLINE. From FL perspective, after the OFFLINE discussion I think the problem statement in the FFS is ill-posed. That ‘the UE being configured for only 1 PCI’ can be coherent with inter-cell BM sounds quite peculiar/absurd at least to me ☺ So basically there is no need to resolve the FFS.]  Proposal 2.B~2.E: Support |
| NTT Docomo | 2.A: Not support. Agree with MediaTek.  [Mod: See comment to MTK and Nokia]  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.  [Mod: Revised to assumption only from RAN1 perspective, for Rel-17]  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.  [Mod: I agree there is benefit. Sadly those 14 companies cannot even agree whether L1 or MAC CE should be used ☹ But I can give it one more round to see if those 14 companies can converge.] |
| 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.  [Mod: Done]  **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.  [Mod: Done]  For 2.C, support  For 2.D, Fine  For 2.E, do we have detailed discussion on this? Suggest to discuss in this meeting further.  [Mod: See comment to Docomo] |
| 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.  [Mod: No. Your proposed wording is inconsistent with the wording of the FFS.  On Rel.17 beam indication enhancements for inter-cell 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) apply to:   * Both joint TCI and separate DL/UL TCI * FFS: For separate DL/UL TCI, whether the indicated DL TCI and UL TCI are associated with SSBs of a same 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”.  [Mod: No. Check the copied agreement above. If what you said about the default were true, the FFS wouldn’t be necessary at all. Actually, without any additional agreement or conclusion, the so-called default would be no restriction]  **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.  [Mod: See revision and see comment to MTK and Nokia]  **Conclusion 2.B**: This would seem to be within the RAN4 scope – we do not see the RAN1 specification impact.  [Mod: See revision (added ‘RAN1 assumes’ which should be ok to you now – LS to RAN4 can be sent later)]  **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.  [Mod: This is to resolve an FFS – see comment to Samsung. But I am not sure how your comment relates to the issue at hand]  **Conclusion 2.E:** Support |
| ZTE | **For differential RSRP(Issue-2.7):** In order to report beams of serving cell and neighboring cell in one reporting and increase diversity and robustness of beams, the offset of L1-RSRP between beams of different cells can be larger than offset of L1-RSRP between beams of one cell. Then, in our views, differential RSRP should be performed between beams of each of non-serving/serving cell. Specifically, the UE reports the largest L1-RSRP per non-serving cell/serving cell using absolute value and then reports the differential L1-RSRP of remaining beams of the non-serving/serving cell using differential L1-RSRP.  [Mod: I tend to agree with you. This will be discussed in the next round(s)]  **Conclusion 2.A**: In general, we have two types of maximum number: 1) from UE perspective, 2) from spec perspective. If our understanding is correct, the proposed conclusion is to further leave 2) to UE feature discussion besides for 1) that has been agreed, right?  [Mod: More or less. But more importantly I believe the FFS for selecting alt1 or alt2 is ill-posed – see comment to MTK and Nokia]    **Conclusion 2.B**: No further discussion/enhancement in Rel-17 is needed in our views. The detailed issue can be left to RAN4.  [Mod: See revision]  **Conclusion 2.C/D**: Support.  **Conclusion 2.E**: Not support. We share the same views with NTT DOCOMO and QC that some further detailed discussion should be made during this meeting. |
| FGI/APT | **Conclusion 2.C**: Support  **Proposal 2.D:** Support |
| Nokia | Conclusion 2A: We need to decide there can be two PCIs in activated MAC-CE or not. Other numbers, larger than two PCIs, can be decided in UE capability discussion.  [Mod: See comment to MTK – note that the PCI info is implicitly included in the QCL info (indirect QCL to ‘non-serving’ SSB) of each TCI state. Without any additional restriction, the NW can activate any set of TCI states via MAC CE thereby allowing activation of TCI states associated with 2 PCIs. Whether this can be done to a UE is of course dependent on UE capability 🡪 UE feature discussion, as Apple correctly stated in OFFLINE]  Conclusion 2C: Even though we mentioned DL/UL TCI shall be associated with the same PCI, having a UL towards the serving cell may be ok while DL is coming from the other PCI. However, we are not sure about the other possibility that the DL from serving cell, while UL transmission is towards the other PCI.  [Mod: Good point. It seems we need more discussion based on your observation here] |
| Futurewei | Proposed conclusion 2.A: We are ok with Qualcomm’s revision.  Proposed conclusion 2.B: Not support. We share the same view as NTT Docomo.  Proposed conclusion 2.C: Support.  Proposal 2.D: Support.  Proposed conclusion 2.E: Need further discussions. |
| Intel | **Proposed Conclusion 2.A:** We don’t think this conclusion captures the intention of the somewhat strange options from the agreement in the last meeting. For inter-cell beam management to work, UE needs to support at least one PCID which is different from that of the serving cell. Whether it supports active TCI associated with more than one PCID can be UE capability which would determine if DCI based inter-cell beam switching is possible or only MAC-CE based beam switching is allowed. This particular conclusion is redundant.  [Mod: See comment to MTK and Nokia]  **Proposed conclusion 2.B:** Do not support. First of all, this should not be a conclusion but rather an agreement is needed to say that such restriction is introduced. The introduction of this timing restriction is totally artificial and makes the feature less applicable. Technically, there is no need for this since inter-cell beam management is a DPS scenario with no simultaneous reception unlike the mTRP case.  **Proposed conclusion 2.C:** OK  **Proposal 2.D:** OK. We should clarify that if MTRP agrees on two values X1 and X2, it is not required in inter-cell beam management. Only a single value of X is sufficient.  [Mod: Good point. Let’s wait what 8.1.2.2 gives us]  **Proposal 2.E:** Given that we have had absolutely no technical discussion on this issue, it seems a bit premature to propose this as a conclusion. |
| Apple | **Proposal 2.A:** Support  **Proposal 2.B:** Support  **Proposal 2.C:** The WID says UE only communicated with one cell, we think this conclusion is not aligned with the WID  [Mod: No. The WID says:  “For inter-cell beam management, a UE can transmit to or receive from only a single cell”  DL reception has to come from a single cell (the meaning of DPS). Likewise, UL transmission has to go to a single cell. But it doesn’t say that both DL and UL have to correspond to the same cell. See comment to Samsung and Nokia.]  **Proposal 2.D:** In AI 8.1.2.2, there may be several values of X with regard to different SSB configurations, e.g. SSBs from different cells in overlapped or non-overlapped resources, is the proposal to consider more than 1 X as well?  [Mod: ‘More than 1 Xs’ seems relevant only for inter-cell mTRP – see comment to Intel]  **Proposal 2.D:** We see some arguments that event-driven inter-cell beam reporting could have similar functionality as BFR, but currently CBD RS can only come from serving cell. If event based inter-cell beam reporting is not acceptable, can we consider the following proposal?   * **On inter-cell beam management, support to configure non-serving cell SSB as CBD RS**   [Mod: This could be a good compromise to be discussed in the next round(s)] |
| OPPO | **Proposal 2.A:** Ok with the revision by Qualcomm.  **Proposal 2.B:** Why the SSB is excluded here? SSB shall be included here. Suggest to revise the proposal as follows:  **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.  [Mod: Done]  **Proposal 2.C:** Share the same understanding as Apple.This proposed conclusion kind of implies that the UE will communicate with more than one cell, which is aligned with the WI.  [Mod: No. See comment to Apple, Samsung, Nokia]  **Proposal 2.D:** Even when the UE is configured with more than one PCIs different from serving cell PCI for measurement in RRC, the UE shall not be triggered or activated to measure more than PCIs for L1-RSRP measurement simultaneously. Because the L1-RSRP measurement is mainly used to find the best TCI state for the target non-serving cell TRP.  **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 configured with L1-RSRP measurement ~~measures~~ with up to X PCIs different from the serving cell PCI in RRC. * When more than one PCIs different from the serving cell PCI are configured in RRC, the UE is expected to be triggered or activated to measure more than one PCIs different from the serving cell PCI simultaneously. * Additional restriction may be added by RAN4   [Mod: OK]  **Conclusion 2.E: Support.** |
| Mod V14 | Revised proposals |
| Xiaomi | Conclusion 2A, support  Conclusion 2B, support  Conclusion 2C, support  Proposal 2D, support  Proposal 2E, not support. We prefer to support event-driven inter-cell beam reporting. |
| vivo | **Proposed conclusion 2.A:** OK with the latest version.  **Proposed conclusion 2.B:** On Rel-17 enhancements for inter-cell beam management and inter-cell mTRP, for SSB-based L1 measurement, if limited within SMTC, legacy neighbor cell measurement can be reused as much as possible, and introducing the restriction is also redundant. Therefore, the receiving time assumption only applies for inter-cell beam measurement based on SSB outside the SMTC window.  **Revised 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 the serving cell is within one CP length associated with the SCS of the active DL BWP when the received signals are outside of SMTC.  **Proposed conclusion 2.C:** OK  **Proposal 2.D:** OK with the latest version. Besides the value of Nmax, another issue of SSB-based L1-measurement that when the time domain of SSB(s) with PCI(s) same as the serving cell for L1/L3 measurement overlaps with that of SSB(s) with PCI(s) different from the serving cell for L1 measurement, UE measurement behavior needs to be clarified. Therefore, we add one FFS as follows:  **Revised 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 * ~~When more than one PCIs different from the serving cell PCI are configured in RRC, the UE is expected to be triggered or activated to measure more than one PCIs different from the serving cell PCI simultaneously~~ * Additional restriction may be added by RAN4 * FFS: UE measurement behaviour when SSBs associated with different PCIs overlap.   **Proposed conclusion 2.E:** OK |
| LG | Conclusion 2.A: Support  Conclusion 2.B: Support  Conclusion 2.C: Support  Proposal 2.D: Support  Conclusion 2.E: Not support. We share the same views with DOCOMO, Qualcomm, Futurewei and Intel that further detailed discussion should be needed and the most companies including Alt1 and Alt2 consider that even-driven beam reporting is beneficial. |
| Fraunhofer IIS/HHI | Conclusion 2.C: Need further discussion based on Nokia’s comment.  Conclusion 2.E: Support |
| InterDigital | Conclusion 2.A: Support  Conclusion 2.B: Support  Conclusion 2.C: Support |
| AT&T | 2.A: ok  2.B: don’t see a strong argument for having or “assuming” this timing restriction for inter-cell BM  2.C, 2.D: support  2.E: agree with deferring this to later in the meeting since event-driven reporting is beneficial and supported by a considerable number of companies |
| Qualcomm | For 2.D, we don’t think mandating all UEs to measure X PCIs simultaneously is a reasonable assumption. Because this requires UE to have multiple active panels to measure each PCI with the best panel. The baseline should be TDMing measured SSBs for UE that can only measure with one active panel at each time. But some UE may be able to measure overlapped SSBs simultaneously to reduce latency. So we suggest to differentiate different SSB L1 measurement behaviors as UE capability.  **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 * ~~When more than one PCIs different from the serving cell PCI are configured in RRC, the UE is expected to be triggered or activated to measure more than one PCIs different from the serving cell PCI simultaneously~~ * Whether UE can simultaneously measure overlapped SSBs with different PCIs and corresponding supported maximum # of overlapped SSBs for measurement is up to UE capability * Additional restriction may be added by RAN4 |
| Spreadtrum | **Proposed conclusion 2.A**: We agree with FL that selecting alt1 or alt2 is ill-posed. Regarding the proposed conclusion, what’s new comparing with the previous agreement from last meeting?  **Proposed conclusion 2.B**: Support.  **Proposed conclusion 2.C**: Support.  **Proposal 2.D:** By reading OPPO’s comments, it seems there’s a typo in the added bullet. We suggest to fix it as below.  **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 * When more than one PCIs different from the serving cell PCI are configured in RRC, the UE is not expected to be triggered or activated to measure more than one PCIs different from the serving cell PCI simultaneously * Additional restriction may be added by RAN4   **Proposed conclusion 2.E:** Fine. |
| Sony | **Proposed conclusion 2.A:**  We share the same understanding with FL that it sounds absurd when UE is configured with only PCI (including serving cell), but it is expected to work for either inter-cell multi-TRP or inter-cell BM. So we support the conclusion to make it clear.  **Proposed conclusion 2.B:**  Support in principle. In our view, the merit of assuming DL receptions from multi-TRP within a CP not only benefits simultaneous Tx from multi-TRP, but also consecutive DL reception from slot to slot by avoiding inter-symbol or inter-slot interference. Of course, that’s RAN1’s assumption or UE’s assumption, not exact NW’s implementation.  **Proposal 2.D:**  We are fine with the direction. By reading the comments from OPPO, we think there is one key word missing, i.e. “not”. But if I get it wrong, please feel free to educate.   * When more than one PCIs different from the serving cell PCI are configured in RRC, the UE is not expected to be triggered or activated to measure more than one PCIs different from the serving cell PCI simultaneously   **Proposed conclusion 2.E:**  We also think the event-driven reporting needs some serious discussion in this RAN1 meeting.  In our observation of Issue 2.5, both Alt.1 and Alt.2 are driven by undefined event(s), the diverging part is either to use L1 signaling or MAC CE signaling for reporting. It seems reasonable to define such event(s) first which can be followed by signaling design. |
| Huawei, HiSilicon | Added our preferences to table above.  Proposed conclusion 2.A: “decided” 🡪 “decide”.  Proposal 2.D: We are not sure if it is correct to add “not” as suggested by Sony.  We added Issue 2.8 on QCL assumption for paging reception after being activated with only one TCI state associated with PCI different from serving cell. We believe this is an important issue to discuss/clarify and we appreciate views from companies. |
| Ericsson | Proposed conclusion 2.A: OK, now the context is clear – it is only related to activated TCI states. In that case, could we clarify:  **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 that are associated with activated TCI states will be decided as a part of UE feature discussion.   * Decided in conjunction with inter-cell mTRP, where the candidate value(s) include at least 1   Proposed conclusion 2.B, 2.C: OK  Proposal 2.D: OK  Proposed conclusion 2.E: OK  We agree with Huawei that it would be relevant to consider small changes to simplify paging reception. The restriction that the UE only monitors P-RNTI in CSS seems unnecessary. |
| MediaTek | Proposed conclusion 2.A: Thanks FL’s clarification. We are fine with Ericsson’s update with one minor structure change to make it more clear:  **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.   * Decided in conjunction with inter-cell mTRP, where the candidate value(s) include at least 1   Proposal 2.D: Share similar view with Spreadtrum and Sony, “not” is need to be added in the proposal.  Proposed conclusion 2.E: Support the conclusion since we don't see clear gain from event-driven beam reporting. Even we introduce a similar triggering event as L3 measurement reporting (e.g., a neighbouring cell becomes offset better than the serving cell), the serving cell cannot be changed based on Rel-17 inter-cell BM. Consider the spec effort, we prefer to discuss it in Rel-18 mobility enhancement.  We would like to add one important issue for inter-cell BM. In RAN1#106, it was agreed that non-UE dedicated channels/signals cannot share the Rel-17 TCI state indicated by Rel-17 MAC-CE/DCI-based beam indication if the TCI state is associated with a PCID different from the serving cell. However, non-UE dedicated channels/signals is too vague, thus a clear definition is necessary.  **Issue 2.9: Definition of “non-UE dedicated channels/signals” for inter-cell BM.** |

### Issue 3 (beam indication signaling medium)

Table 5 Summary: issue 3

|  |  |  |
| --- | --- | --- |
| **#** | **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)  **Alt2**: vivo, Samsung (1st), 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, inter-cell), MTK (panel-swicthing, inter-cell with time difference greater than CP), FGI/APT (multi-panel), LG (multi-panel), IDC (multi-panel)  **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, NEC  **New dedicated DCI format for beam indication**:  **Group-common DCI**: Sony, Intel, MTK, NTT Docomo, Qualcomm  **When more than one TCI codepoints are activated by MAC CE, the activated TCI state(s) for the lowest codepoint is/are applied**: Huawei/HiSi, vivo (until DCI is indicated), Convida (after MAC CE activation), MTK (until DCI is indicated, only for the case if the currently applied TCI state is not one of the activated TCI states), NTT Docomo, NEC |
|  |  |  |

The following observation can be made:

* 3.1: Alt1 represents 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

|  |  |
| --- | --- |
| **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.  [Mod: Thanks for the explanation and yet being open-minded]  **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. |
| ZTE | **Proposal 3.A:** Generally speaking, from gNB perspective, we may only need a reference SCS for determining a sufficient Y value (not only for UE/gNB beam switching, but also for gNB decoding and resource scheduling algorithm). Therefore, we do not identify the necessity of a complicated rule for selecting the reference SCS. Analogous to Rel-16 multi-CC simultaneous transmission, we prefer to reuse the solution of being based on SCS of Acknowledgment, i.e., Alt3. Regarding the slot boundary issue as MTK mentioned, it also occurs in Rel-16 and can be assumed as a corner case that is up to implementation.  Then, we identify an remaining issue for **DCI without DL assignment**: For semi-static HARQ-ACK codebook, the virtual PDSCH should be assumed in the same slot as the DCI without DL assignment, and the time-domain allocation of the virtual PDSCH within the given slot is determined according to the SLIV of indicated TDRA field, rather than SLIV+K0 in the TDRA. It is the same as legacy mechanism for SPS PDSCH release. Some more details can be found in Section 2.2.2 in our contribution R1-2108870. |
| Convida | **Proposal 3.A:** Support |
| FGI/APT | **Proposal 3.A**: We prefer Alt. 2 and have similar understanding as Samsung. |
| Nokia/NSB | Proposal 3.A: Support  3.2: it would be good to understand what would be the impacts to signalling if different Y values for different purposes are needed. For instance, in case of multi-panel, should the gNB be aware of whether the UE needs to switch also panel or not in beam switching. Regarding inter-cell beam management, proposed conclusion 2.B may prevent such case in Rel17, i.e. inter-cell with time difference greater than CP. |
| Intel | **Proposal 3.A:** OK    **Issue 3.3:** We think the issue of mapping the beam indication ACK/NACK to high priority is important since if these are dropped due overlap for some reason, then the link may fail and we may go into further time consuming procedures like BFR rather than a simple beam switch. |
| Apple | Proposal 3.A: Support  For issue 3.3, in addition to ACK enhancement, even with some understanding for current agreement (only ACK is counted), there is one issue to be clarified on the interpretation of TCI indication. Currently TCI is present in DCI, and no matter the DCI is used for data scheduling only or for beam indication + data scheduling, TCI is always there. Then for one UL slot with ACK, UE may report ACK for multiple DCIs from multiple CCs, then which TCI should UE use after transmitting this ACK? |
| OPPO | Proposal 3.A: support. |
| Mod V14 | Revised proposals |
| Xiaomi | Support the proposal 3A  For issue 3.3, if the DCI formats 1\_1/1\_2 with DL assignment for beam indication is decoded correctly, but the PDSCH is not decoded correctly, HARQ NACK will be feedback. In this case, gNB can’t use the new beam for next PDCCH, which may result in BFR. |
| vivo | Support with the following revision to make the proposal clear. Otherwise, the Y value would be dependent on the worst case.  **Proposal 3.A**:  For ‘FFS whether Y is configured per BWP, per CC or per band or per SCS, or independent of BWP/CC/SCS”, we think the Y values can be configured per SCS per CC list, where each Y value corresponds to SCS of target BWP and SCS of UL carriers carrying PUCCH. For CA case, to align the timeline of beam application time across CCs, the smallest SCS among the target CCs and the UL carrier carrying ACK of beam indication DCI is used to determine the first slot and Y symbols. So we propose   * The Y symbols are configured per SCS and dependent on SCS of target BWP and SCS of the UL carrier carrying ACK of beam indication DCI, one of the configured Y symbols is used. |
| LG | Added our views in the table  Issue 3.2: We support defining different Y value in case of panel switching.  Issue 3.3: Our understanding is same as Docomo that indicated beam is updated after the ‘ACK’ agreed already. No further enhancement is needed.  Issue 3.4: It is beneficial to support automatic update of the PUCCH spatial relation from the updated spatial relation for PUSCH by existing DCI format 0\_1/0\_2 |
| InterDigital | Our views are added in the table. We also support having different Y values in case of multi-panel. |
| Qualcomm | Support 3.A |
| NEC | For Issue 3.3, we share similar view as DoCoMo that previous agreement already means indicated beam applied only after ACK is reported. In addition, we should discuss the case of HARQ multiplexing, as in a HARQ codebook, there may be multiple HARQ-ACK reporting corresponding to different PDCCH/PDSCH, then it should be discussed that which one of multiple indicated beams should be applied after the same application timing.  For Issue 3.4, support in general. While maybe a little update is needed, for example, in case of separate DL/UL TCI state, and if the lowest codepoint corresponds to DL-only or UL-only, then we need the other codepoint for the TCI state not included in the lowest codepoint.  **When more than one TCI codepoints are activated by MAC CE, the activated TCI state(s) for the lowest codepoint including DL TCI state and/or UL TCI state is/are applied for downlink and/or uplink, respectively, in case of separate DL/UL TCI, and the activated TCI state for the lowest codepoint is applied for both downlink and uplink in case of joint TCI.** |
| Spreadtrum | **Proposal 3.A:** Support.  For issue 3.4, we are OK to discuss default TCI state after MAC CE activation. On the other hand, we think it’s too late to introduce new signaling design for TCI state indication. |
| TCL | **Proposal 3.A**: Support |
| Huawei, HiSilicon | Added our preferences to table above.  Issue 3.2: In addition to multi-panel case, it is also necessary to allow for different BAT for intra-cell and inter-cell beam indication.  Issue 3.3: It appears necessary to discuss whether NAK can be used to confirm beam indication with DCI with DL assignment. |
| Ericsson | On Issue 3.3: how to interpret the beam indication ACK/NAK is up to NW implementation: the UE behavior is clear: X symbols after the sending the AC/NAK, the UE would switch the beam, unless instructed otherwise. |

### Issue 4 (MP-UE)

Table 7 Summary: issue 4

|  |  |  |
| --- | --- | --- |
| **#** | **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, ZTE * **3**: Samsung, Qualcomm   **#SRS resources in each set:**   * **UE reporting**: vivo, Qualcomm   **#SRS ports in each set**   * **1, 2, 4**: Samsung, Qualcomm, ZTE |
|  |  |  |

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 logical index is introduced that is associated to a UE capability, e.g. number of SRS ports, coherence type (TBD)
* 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)
  + Note: the correspondence between a CSI-RS and/or SSB resource index and the logical index is determined by the UE (analogous to Rel-15/16)
* Support UE reporting of maximum number of SRS ports and coherence type for each logical index as a UE capability
* 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, where the SRS resource set should be aligned with the UE capability for the logical index
* UE shall not expect gNB to trigger the SRS in different resource sets overlapped in time domain

Table 8 Additional inputs: issue 4

|  |  |
| --- | --- |
| **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   [Mod: See revised per Nokia]  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.  [Mod: Scheme 2 includes 3 different schemes – can the proponents converge to one scheme so that the group can have a more meaningful discussion?] |
| ZTE | **Proposal 4.A**: Support. In our views, both schemes support UE reporting capabilities related to panel. Panel entity is explicitly considered/defined in scheme 1 which is clearer than scheme 2 logically, especially considering the same UE capability (e.g., same number of supported SRS antenna ports) for different panels. Therefore, we prefer to go with Option-1 as a starting point and meanwhile consider some detailed procedure as discussed in Scheme-2. Specifically,   * In order to dynamically report the panel related UL transmission capabilities, such as maximum number of SRS ports, number of UL transmission layers, per panel entity, the NW may confirm/configure a list of panel related capabilities UE reported explicitly, which can be called as transmission mode(s), as a response.   + The NW configures an association between transmission mode indexes and the panel entity index or rank/number of SRS antenna ports, and then based on the legacy beam reporting or MAC-CE, UE can report the respective transmission mode indexes corresponding to each of reported SSBRI/CRI.   + In order to guarantee the reliability of MPUE operation, the gNB response for the above report is necessary. For instance, the above results in beam report or MAC-CE are applied X symbols after receiving gNB acknowledge for the report. |
| Nokia/NSB | Proposal 4.A: We think that there is some common ground in the Scheme 1 and 2. In both schemes there is a need for a logical index that would be associated to a panel specific capability. In other words, if we are having possibility to have different capabilities among the UE panels e.g. in terms of number antenna ports, there is a need to be able to report SSB resource index and/or CSI-RS resource index corresponding the logical index so that the correct SRS resource set is triggered for correct UL beam pair link. So, essentially the following components would be needed:  • a logical index that is associated to panel specific capability/capabilities  • association between SRS resource set(s) and the logical index  • reporting of SSB resource indices and/or CSI-RS resource indices per logical index  We propose the following update for the proposal:  **Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection,   * A logical index is introduced that is associated to a UE capability like number of SRS ports, coherence type * A logical index is ~~panel entity~~ reported together with ~~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 logical index ~~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 logical index ~~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 logical index~~panel entity~~   [Mod: Done] |
| Intel | **Proposal 4.A:** Do not support. Tend to agree with Ericsson. We should also consider feasibility of finishing the feature at this late stage.  [Mod: See comment to Ericsson. Given the current shape of Scheme 2 (3 different schemes merged into one, relatively new compared to scheme 1), Scheme 2 seems to have more open issues ☹ ] |
| Apple | **Proposal 4.A:** For this proposal, since we increased number of SRS resource sets, to avoid simultaneous multi-panel transmission, we suggest we add another sub-bullet   * **UE shall not expect gNB to trigger the SRS in different resource sets overlapped in time domain**   [Mod: I think this is reasonable] |
| OPPO | **Proposal 4.A:** do not support.The discussion shall start from scheme 2 in previous agreement. And similar to Intel, we also have concern on finishing this feature within rel17.  [Mod: See comment to Ericsson and Intel – your concern on ‘finishing this feature within rel17’ is evidently more pronounced with Scheme 2 (your preference) ☺] |
| Mod V14 | Revised proposal |
| Xiaomi | Support proposal 4A. Scheme 1 is clearer than scheme 2 to associate a logical index with a panel and to indicate different parameters for different logical index. |
| vivo | **Proposal 4.A:** support in principle.  Because the corresponding panel entity for one RS resource may vary and one RS resource may correspond to multiple UE panels, to avoid the misalignment between gNB and UE, the direct way is to indicate an index/ID in beam report to inform gNB of the UE panel corresponding to each SSBRI/CRI. Or the index/ID is introduced in report configuration/activation to enable beam management and beam report for the specific UE panel.  In beam report, the UE panels corresponding to the indexes/ID can be considered as active. These indexes/IDs also can be used to facilitate the report of panel level UE capability, where an index/ID corresponds a parameter list, e.g. including UL rank, number of SRS antenna ports and coherence type. If per panel UE capability is supported, the parameters of SRS resource set in Rel-15 can be reused. The number of SRS resource in SRS resource set can be included in the parameter list for different UL measurement requirements. Then SRS resource set ID is used as the index/ID or associated with the index/ID.  **Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection,   * A logical index/panel ID is introduced that is associated to a UE capability, e.g. number of SRS ports, coherence type (TBD) * 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)   + Note: the correspondence between a CSI-RS and/or SSB resource index and the logical index/panel ID is determined by the UE (analogous to Rel-15/16)   + Note: The index/ID is valid until next beam report. * Support UE reporting of maximum number of SRS ports and coherence type for each logical index/panel ID as a UE capability * 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, where the SRS resource set should be aligned with the UE capability for the logical index/panel ID * Support UE reporting supporting number of SRS resources for each SRS resource set. * UE shall not expect gNB to trigger the SRS in different resource sets overlapped in time domain |
| LG | Support the proposal. Updated proposal is also fine to us. |
| InterDigital | Support the updated version (by Moderator) of Proposal 4.A. Open to include Opt3 (coherence type) from Scheme 2 on top of the main Proposal 4.A based on Scheme 1. |
| AT&T | Support this proposal. We are ok with the changes from Nokia, capturing the common ground between scheme 1 and scheme 2. |
| Samsung | Two comments:   * 2nd bullet: clarify that a logical index is reported together with CRI/SSBRI * 1st bullet: suggest to include TPMI as an example in 1st bullet.   These are shown in yellow.  **Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection,   * A logical index is introduced that is associated to a UE capability, e.g. number of SRS ports, coherence type, TPMI (TBD) * A panel entity corresponds to a logical index reported together with a reported CSI-RS and/or SSB resource index in a beam reporting instance (i.e. Opt1-1 per RAN1#104-bis-e agreement)   + Note: the correspondence between a CSI-RS and/or SSB resource index and the logical index is determined by the UE (analogous to Rel-15/16) * Support UE reporting of maximum number of SRS ports and coherence type for each logical index as a UE capability * 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, where the SRS resource set should be aligned with the UE capability for the logical index   UE shall not expect gNB to trigger the SRS in different resource sets overlapped in time domain |
| Qualcomm | For 4.A,   * To our understanding, it seems necessary for UE to report the logic index together with a reported DL RS. Otherwise, gNB has no clue the related panel info. So suggest to emphasize it. * We also suggest to clarify that the logic index and related panel capabilities can be common across multiple CCs based on UE capability.   **Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection,   * A logical index is introduced that is associated to a UE capability, e.g. number of SRS ports, coherence type (TBD) * ~~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)~~   + ~~Note: the correspondence between a CSI-RS and/or SSB resource index and the logical index is determined by the UE (analogous to Rel-15/16)~~ * The correspondence between a CSI-RS and/or SSB resource index and the logical index is determined by the UE (analogous to Rel-15/16) and is informed to NW   + FFS: Detailed design of how to inform the correspondence to NW * Support UE reporting of maximum number of SRS ports and coherence type for each logical index as a UE capability * The logic index and associated capability can be common across a set of BWPs/CCs based on UE capability   […] |
| NTT Docomo | Support the proposal.  Also agree with QC that it is important that the logical index is informed to NW together with SSBRI/CRI. |
| Spreadtrum | **Proposal 4.A:** Support in principle. A logical index is needed for both scheme 1 and scheme 2. Besides, since the correspondence between a CSI-RS and/or SSB resource index and the logical index is determined by the UE, the next level question will be whether/how to inform gNB when the association has changed. |
| Sony | Support the direction of finding the common ground between scheme 1 and scheme 2.  Additionally, we share similar view as QC that the correspondence between the reported DL RS and the logical index should be kept, which seems a quite essential part of scheme 1. |
| Huawei, HiSilicon | Similar view as Qualcomm. |
| Ericsson | The modified Proposal 4.A does not seem functional, since the “logical index” is not conveyed to the NW. |
| MediaTek | QC’s version looks good. Some comments as follows:   * We think multiple logical indexes would be needed for MP-UE. * The correspondence between a reported CRI/SSBI and a logical index is informed in the beam report, i.e., along with the reported CRI/SSBI. * Since which UE capability is still TBD, we prefer to add TBD for UE reporting of UE capability for each logical index. * Since which UE capability is associated with logical index still TBD, we prefer to add TBD for UE reporting of UE capability for each logical index.   In summary, we prefer the following update based on QC’s version:  **Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection,   * One or more logical indexes are introduced, and each logical index is associated with a UE capability, e.g. number of SRS ports, coherence type (TBD) * ~~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)~~   + ~~Note: the correspondence between a CSI-RS and/or SSB resource index and the logical index is determined by the UE (analogous to Rel-15/16)~~ * 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: Detailed design of how to inform the correspondence to NW * Support UE reporting of a UE capability, e.g. number of SRS ports, coherence type (TBD) for each logical index * The logic index and the associated UE capability can be common across a set of BWPs/CCs based on UE capability |

### Issue 5 (MPE mitigation)

Table 9 Summary: issue 5

|  |  |  |
| --- | --- | --- |
| **#** | **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, IDC  **No**: vivo (include panel ID), Huawei, HiSilicon |
| 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, Convida * **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, ZTE, Convida   Candidate resource pool:   * **Configured via RRC**: CATT, ZTE * **Configured via RRC using CSI report config**: Samsung, [Nokia/NSB], MTK, IDC |
| 5.4 | Beam vs panel level | **Beam**: IDC, Sony, Nokia/NSB, Qualcomm, MTK, Convida  **Panel**: Huawei/HiSi, Spreadtrum, vivo, Lenovo/MotM, CATT, LG, Xiaomi  **No need to discuss**: Ericsson, ZTE |
|  |  |  |

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 N=1, 2, 3, and 4



Table 10 Additional inputs: issue 5

|  |  |
| --- | --- |
| **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 |
| ZTE | **Proposal 5.A/B**: Support. In our views, even if the P-MPR is panel specific in UE implementation, the UE still can report the same P-MPR values for different reported SSBRI(s)/CRI(s) as a transparent manner. In other words, we tend to agree that N represents the number of selected beams.  For Issue 5.3: In technical, if beam reporting is only based on MPE rather than both MPE and the virtual/real transmission, the UL beam (with low MPE but large path loss) recommended by reporting may be useless, and more power is wasted for keeping the same performance. The UE shall report SSBRI(s)/CRI(s) along with the virtual PHR with the objective of maximizing PHR value, i.e., minimizing the value of P-MPR and PL.   * Besides, DL-RSRP can be derived according to P-MPR and the modified virtual PHR.   Then, regarding candidate pool, we think that a new RRC pool analogous to new candidate RS pool for BFR can be explicitly configured. |
| Nokia/NSB | Proposal 5.A: Support  Proposal 5.B. We see N=1 to restrictive. We would prefer N up to 4.  [Mod: It seems the majority goes this way. Revised proposal] |
| Intel | OK with both proposals |
| Apple | Proposal 5.A: Support  Proposal 5.B: N=1 has already been supported in Rel-16. We suggest to consider N>1 with UE capability, similar to beam report.  [Mod: See revision] |
| Mod V14 | Revised proposal |
| Xiaomi | Proposal 5A: support  Proposal 5B: we think it is better to discussion on N represents the number of panels or beams first. We prefer that N represents the number of panels. |
| vivo | Support Proposal 5.B with following revision, where N value can be determined based on UE capability.  Proposal 5.B: On Rel.17 enhancements to facilitate MPE mitigation, support N=1, 2, 3, and 4   * UE reports supported value of N as a capability.   We don’t support Proposal 5.A with the subbullet. Beam report is dynamically reported while the P-MPR report is in MAC CE. If only one beam is selected for scheduling in the MAC-CE, it would be difficult to match the MAC CE report with the beam report in DCI. |
| LG | Proposal 5.A: Support  Proposal 5.B: Similar comment as Apple. In case of N=1, what is the clear difference compared to the conventional P-MPR scheme? In this regards, we prefer to consider N>1. |
| InterDigital | Our views are added in the table. Support confirming the WA, and we are okay with the updated Proposal 5.A. |
| Samsung | Support both proposals |
| Qualcomm | For 5.B, suggest to add UE capability on N. Vivo’s change is fine. |
| NTT Docomo | Support the proposal 5.A and 5.B. |
| Spreadtrum | Before agreeing on the proposals, we suggest to clarify the definition of N as Xiaomi has commented since the definition of N may affect our understanding of the whole solution. There’re three possible interpretations: (1) the # panels that have MPE issue (2) the total # panels (3) the # panels with/without MPE issue which can be smaller than the total # panels. |
| Sony | Support Proposal 5.1 and 5.B. |
| Huawei, HiSilicon | Added our preferences to table above.  Issue 5.1: We prefer to clarify the meaning of N (panel or beam) before confirming the WA or deciding candidate values of M and N. |
| Ericsson | Proposal 5.1: Support  Proposal 5.2: Support. N is neither the number of beams nor panels: it’s the number of reported measurements. However, it is critical to decide how the UE selects the N measurements. |

### 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), Nokia/NSB (Opt1 + Opt2), IDC  **ALT2**: MTK, NTT Docomo, Qualcomm, Samsung, ZTE, Nokia/NSB, Futurewei, LG  **ALT3**: Qualcomm, Samsung, Nokia/NSB (can be combined with ALT1) |
|  |  |  |

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

|  |  |
| --- | --- |
| **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. |
| ZTE | Considering that only few meetings are left, we should focus on a single above sub-topic. In our views, the reliability and benefits of UE-initialized beam selection should be well justified considering that there is no gNB response, and then we slightly prefer UE-initiated beam activation based on beam reporting. |
| Convida | Propose to postpone to a later release. |
| Nokia/NSB | We think the alternatives are not mutually exclusive. And basically, Alt1 and Alt3 could be merged as also in Alt3 it’s expected that some indication (like CFRA or SRS) provided to the gNB would be used. |
| Intel | It is unfortunate that as a group we agree that Issue 6 is very important for improving beam management performance, but still prefer to defer the issue. At this late state, we agree with Ericsson and prefer to handle in Rel-18. |
| Apple | In our view, Alt1 covers the functionality of Alt2/Alt3, and all the alternatives have similar workload. We suggest we focus on Alt1, which can do a better job that Alt2/Alt3. |
| Mod V14 | Need more inputs – so far ALT1 seems more popular.  On the other hand, from FL perspective I sympathize with Ericsson and Convida ... unless we narrow down to one of the options in ALT1 and resolve most of the FFSs in this meeting, this may be a topic for Rel-18. |
| LG | We have a similar view with ZTE that we need to focus on a single topic due to the limited time for Rel-17. To this end, we prefer to focus on UE-initiated beam activation based on beam reporting since the current beam measurement/reporting is independent to CORESET/PDSCI TCI state configuration. |
| InterDigital | Our views are added in the table. We support Alt1 as UE-initiated beam selection within a beam group given by the NW-indication in which the UE is allowed to do the beam selection. |
| NEC | We are fine to postpone this to Rel-18. |
| Huawei, HiSilicon | Similar view as Ericsson, Convida, Intel, and NEC – postpone to R18. |

# 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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