**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 * **No (increase to 16):** Samsung   **Max total 128 configured TCI states (same as Rel.15/16):**   * **Support:** vivo, Lenovo/MotM, CMCC, Nokia/NSB, OPPO, MTK, Fujitsu, Qualcomm, IDC, Spreadtrum, Futurewei * **No (increase to 256):** ZTE, Ericsson, Samsung, APT/FGI, LG, Intel, NTT Docomo, Convida |
| 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  **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 * **Not support**:   **1.C.2:**   * **Support**: MTK, Samsung, ZTE, Intel, vivo, CMCC, Fujitsu, Qualcomm, Ericsson, Convida, Nokia/NSB, Futurewei * **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  **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  **Not support**: |
| 1.6 | Offline proposal 1.F (below)  Note: The wording of proposal can be further refined (please describe in Table 2) | **Support**: Ericsson (Opt 1), MTK, Intel (Opt2), Apple (Opt1), vivo, Spreadtrum, Samsung, CMCC, ZTE, Fujitsu, Lenovo/MotM, IDC, NTT Docomo, Qualcomm, Nokia/NSB, Futurewei  **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  **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  **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 (10)**: CMCC, Ericsson, Futurewei, Huawei/HiSi, Fraunhofer IIS/HHI, IDC, Sony, Apple |
| 1.10 | Additional source RS type for DL QCL Type-D reference for DL common UE-dedicated reception on PDSCH and all/subset of 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 (4):** ZTE, Samsung, MTK, vivo, Qualcomm * **No (8):** 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 * **No (10):** 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  **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)  **No**: |
|  |  |  |

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

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

The following observation can be made:

* ...

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

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

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

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

* For DL channels/signals that do not share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH/PDCCH (via Rel-17 MAC-CE/DCI TCI state update), all the QCL rules defined in section 5.1.5 in 38.214 are supported
  + Note: For CSI-RS used to provide QCL indication for non-UE dedicated channels, the CSI-RS should only be QCLed with SSB of the same PCID as that from the serving cell
* For DL channels/signals that share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH/PDCCH (via Rel-17 MAC-CE/DCI TCI state update), only the following options on source RSs and QCL-Types are supported
  + Option 1: TRS is configured for QCL-TypeA ~~indication~~ source RS and CSI-RS for BM is configured for QCL-TypeD ~~indication~~ source RS
  + Option 2: TRS is configured for QCL-TypeA and QCL-TypeD ~~indication~~ source RS
  + Note: For inter-cell beam management, SSB with PCID different from that from the serving cell can be used as a QCL Type-D source RS for CSI-RS for BM and/or TRS

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

*For joint TCI and DL-only TCI*

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

*For UL-only TCI*

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

*On Rel-17 unified TCI framework, support common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs:*

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

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

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

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

*...*

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

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

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

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

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

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

**Proposal 1.H**: On Rel.17 unified TCI framework, when the setting of (P0, alpha, closed loop index) for PUSCH, PUCCH, and/or SRS are associated with UL or (if applicable) joint TCI state per BWP:

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

Table 2 Additional inputs: issue 1

|  |  |
| --- | --- |
| **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.  **Proposal 1.G**: On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, “beam alignment” also pertains to the following events when both PL-RS and UL TCI spatial relation RS are not CSI-RS for BM:   * The PL-RS is identical to the QCL Type-D RS of UL TCI spatial relation RS * The QCL Type-D RS of PL-RS is identical to the UL TCI spatial relation RS * The QCL Type-D RS of PL-RS is identical to the QCL Type-D RS of UL TCI spatial relation RS   Proposal 1.H: Support |
| NTT Docomo | Proposal 1.A: We prefer to increase the max number of configured TCI states.  Proposal 1.B: **Question:** Is it correct understanding that the 1st bullet means DL channels/signals with Rel.15/16 TCI state and 2nd bullet means DL channels/signals with Rel.17 TCI state?  Proposal 1.C.1: Support.  Proposal 1.C.2: Support. It is consistent with Rel.15/16.  Proposal 1.D: Support.  Proposal 1.E: Support.  Proposal 1.F: Support. We assume CSI-RS includes TRS. We think Opt.1 is straightforward.  Proposal 1.G: Support.  Proposal 1.H: **Question**: What does "Optionally" imply? Do we consider the case that multiple settings are configured but the association is not configured? |
| Qualcomm | For 1.A, suggest to add “if agreed” after the DL-only+UL-only TCI state. I think we haven’t agreed that each TCI state can serve as both DL-only and UL-only.   * For the number of configured TCI states (including joint TCI state(s), DL-only TCI state(s), UL-only TCI state(s), and/or DL-only+UL-only TCI state(s) if agreed), the largest configurable value is 128   For 1.B-1.H, support |
| Samsung | **Proposal 1.A**: We prefer to increase both the number of activated TCI state codepoints to 16, and the number of RRC configured TCI states to 256.  **Proposal 1.B**: Proposal 1.B has two parts; we are fine with the first part which covers DL channels/signals that share the TCI state of dedicated channels. However, we would like to clarify if this applies only to Type-D QCL relations or all QCL relation types. So far, we have only agree Type-D and Type-A QCL Types for the Rel-17 TCI state.  We are fine with the second part dealing with UE dedicated DL channels and DL channels/signals that share the TCI state of UE dedicated DL channels.  We prefer to keep the table to have all the details clearly spelled out and avoid any potential misunderstanding or ambiguity.  **Proposal 1.C.1:** Support  **Proposal 1.C.2:** Support  **Proposal 1.D:** Support  **Proposal 1.E:** Support  **Proposal 1.F:** Support. On the decision to decide between option 1 and option 2, if option 2 is configured, it is up UE implementation to decide if one (which one) or both antenna ports are used for PL estimation.  **Proposal 1.G:** Support. We suggest a small update to reflect the fact that the source RS of an UL TCI state can be an SRS, which doesn’t really have a QCL Type-D source RS, but rather a source spatial relation RS (that can be a DL RS)  **Proposal 1.G**: On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, “beam alignment” also pertains to the following events:   * The PL-RS is identical to the QCL Type-D RS or source spatial relation RS of UL TCI spatial relation RS * The QCL Type-D RS of PL-RS is identical to the UL TCI spatial relation RS * The QCL Type-D RS of PL-RS is identical to the QCL Type-D RS or source spatial relation RS of UL TCI spatial relation RS   **Proposal 1.H:** We prefer that multiple setting are configured by RRC (i.e. a list of settings) and then the association is done MAC CE. The case of no association by MAC CE is the case when there is one setting configured, hence there is no need to do association.  We would like to clarify if the multiple settings configure by RRC are common for all channels or a different list of settings is used for each channel. |
| Ericsson | **Proposal 1.A:** OK.  **Proposal 1.B:** we prefer to reuse the Rel16 QCL rules fully, and we do not see why there is a need to describe the common beam operation separately. The only rules that are applicable are those applicable for PDCCH/PDSCH DMRS, 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.  **Proposal 1.C.1**: Don’t support – the proposal is inconsistent. In Rel-16, the RS that provides QCL-TypeB must be in the same CC. Would this proposal mean that QCL-TypeB can be derived from an RS on another CC??  **Proposal 1.C.2**: Support.  **Proposal 1.D:** Don’t support, the meaning is unclear. The subbbullets describe the complete procedure, so it is unclear what an additional “configured” in the main bullet would mean.  **Proposal 1.F:** Note that 2-port CSI-RS was discussed at length during the Rel-16 UE features, and the outcome was not really satisfactory. A potential support for 2-port CSI-RS will be subject to UE capability, and unless it is deemed really valuable, it would make sense to state that only 1-port CSI-RS is supported  **Proposal 1.G:** We are ok, but it would seem late to introduce a term for discussion purposes. The specification impact of “beam misalignment” – whatever it means – is still unclear to us.  **Proposal 1.H:** We should only use MAC CE for updates that are time-critical. Changing the TCI – to – PC parameter mapping does not qualify. As RAN1 as a whole has not identified that this is time-critical, it can be left to RAN2. |
| 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:     **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 |   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.  **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.  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 |   **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.  **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. |
| 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.  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.  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.  **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.  **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  **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. 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.  **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.  **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.  **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.  **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. |

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

Table 3 Summary: issue 2

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| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1 | Offline conclusion 2.A (below)  Note: The wording of proposal can be further refined (please describe in Table 4) | **Support**: Fujitsu  **Not support**: MTK, NTT Docomo, Ericsson |
| 2.2 | Offline conclusion 2.B (below)  Note: The wording of proposal can be further refined (please describe in Table 4) | **Support**:, Nokia/NSB, Spreadrum, MTK, LG, Qualcomm, Apple, MTK, Qualcomm, Samsung, Lenovo/MotM, OPPO, NEC, CATT, Sony, ZTE, Xiaomi, Huawei/HiSi, IDC  **Not support**: Futurewei, Intel, NTT Docomo, Ericsson |
| 2.3 | For separate DL/UL TCI, need to add restriction that the indicated DL TCI and UL TCI are associated with SSBs of a same physical cell ID? | **Yes:** OPPO, Nokia/NSB, Samsung, Intel, Apple  **No:** Ericsson, CMCC, Xiaomi, NTT Docomo, MTK, Qualcomm, ZTE, FGI/APT, Futurewei |
| 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  **Alt2:** Spreadtrum, OPPO, Qualcomm |
| 2.5 | Whether to support event-driven inter-cell beam reporting and if so the event definition   * Alt1. Support L1-based event-driven beam reporting for inter-cell beam management and inter-cell mTRP * Alt2. Support MAC CE based event-driven beam reporting for inter-cell beam management and inter-cell mTRP * Alt3. In Rel-17, event-driven beam reporting is not supported for inter-cell beam management and inter-cell mTRP | **Alt1**: Huawei/HiSi, Xiaomi, Intel, Sony, LG, Samsung, Qualcomm (2nd preference), Futurewei  **Alt2**: ZTE, Lenovo/MotM, CATT, Xiaomi, NTT Docomo, Nokia/NSB, Apple, Qualcomm (1st preference), Convida  **Alt3**: 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  **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) |
|  |  |  |

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

The following observation can be made:

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

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

**Proposed conclusion 2.A**: On Rel-17 beam indication enhancements for inter-cell beam management, for the supported Rel-17 MAC-CE-based and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation), the supported number of physical cell IDs different from that of the serving cell will be decided as a part of UE feature discussion.

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

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

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

* Note: X as agreed in AI 8.1.2.2
* When NMAXis configured to be X, the UE measures up to X PCIs different from the serving cell PCI
* Additional restriction may be added by RAN4

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

Table 4 Additional inputs: issue 2

|  |  |
| --- | --- |
| **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  Proposal 2.B~2.E: Support |
| NTT Docomo | 2.A: Not support. Agree with MediaTek.  2.B: Not support. In L1/L2 inter cell mobility, the UE only receives PDSCH from one TRP at a time, and only one Rx chain is needed, irrespective of the time-of-arrival of the PDSCH. So, there is no need to require that all DL signals are received within the CP.  2.C: Support.  2.D: Support.  2.E: Not support. We believe event based beam reporting is beneficial. At least 14 companies support it, and 4 companies are against it. We prefer to continue discussion. |
| Qualcomm | For 2.A, suggest to add the following clarification, because it has been agreed in both Alt1 and Alt2 in the following agreement that UE can only support 1 non-serving PCI for measurement. In this case, the max activated TCI # for non-serving PCI is 1.  …, the supported number of physical cell IDs different from that of the serving cell will be decided as a part of UE feature discussion with candidate value at least including 1.  **Agreement**  On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, select NMAX(the maximum number of RRC configured PCIs different from the serving cell for measurement/reporting) from the following alternatives (to be decided in RAN1#106bis-e):   * Alt1: NMAXis up to UE capability with candidate values of 1 and X.   + Note: X as agreed in AI 8.1.2.2   + When NMAXis configured to be X, the UE measures up to X PCIs different from the serving cell PCI   + Additional restriction may be added by RAN4 * Alt2. NMAX=1   For 2.B, suggest to include SSB as well. All other signals having Rx timing difference < CP implies SSB must be in the CP as well. Also clarify the CP refers to active DL BWP’s SCS.  …, the reception of signals ~~other than SSBs from TRPs with PCIs differen~~t from the non-serving cell compared to that for serving cell is within one CP length for the SCS of active DL BWP.  For 2.C, support  For 2.D, Fine  For 2.E, do we have detailed discussion on this? Suggest to discuss in this meeting further. |
| Samsung | **Conclusion 2.A:** Tend to agree with MTK and NTT Docomo, that this is covered by an earlier agreement.  **Conclusion 2.B:** Support  **Conclusion 2.C:** We think this conclusion can be worded differently:  On Rel-17 beam indication enhancements for inter-cell beam management, for separate DL/UL TCI, there is no consensus in ~~restricting~~ allowing the indicated DL TCI and UL TCI to be associated with SSBs of a ~~same~~ different physical cell ID.  More importantly, what does “no consensus” mean, that UL TCI state and DL TCI state “can be” or “are not allow to be” on cells with different PCIs. We think the default should be “not allowed”.  **Proposal 2.D:** Support  **Conclusion 2.E:** Support |
| Ericsson | **Conclusion 2.A**: Don’t support: if there is a need for RRC signalling, there is a need to define something before going into UE feature discussions. It would seem appropriate to reuse what is designed for inter-cell mTRP.  **Conclusion 2.B**: This would seem to be within the RAN4 scope – we do not see the RAN1 specification impact.  **Conclusion 2.C:** Our understanding is that the inter-cell beam indication will reuse what we have for intra-cell, i.e., that separate is allowed, potentially subject to UE capability.  **Conclusion 2.E:** Support |
| 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.  **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?    **Conclusion 2.B**: No further discussion/enhancement in Rel-17 is needed in our views. The detailed issue can be left to RAN4.  **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.  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. |
| 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.  **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.  **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  **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?  **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** |

### 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  **Alt2**: vivo, Samsung, APT/FGI  **Alt3**: ZTE, Sony |
| 3.2 | Whether to support different values of Y for different cases. If so, details | **Yes**: Samsung (multi-panel), Huawei/HiSi (multi-panel), MTK (panel-swicthing, inter-cell with time difference greater than CP), FGI/APT (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  **New dedicated DCI format for beam indication**:  **Group-common DCI**: Sony, Intel, MTK, NTT Docomo, Qualcomm  **When more than one TCI codepoints are activated by MAC CE, the activated TCI state(s) for the lowest codepoint is/are applied**: Huawei/HiSi, vivo (until DCI is indicated), Convida (after MAC CE activation), MTK (until DCI is indicated, only for the case if the currently applied TCI state is not one of the activated TCI states), NTT Docomo |
|  |  |  |

The following observation can be made:

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

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

**Proposal 3.A**: On Rel-17 DCI-based beam indication, regarding application time of the beam indication for CA, the first slot and the Y symbols are both determined on the carrier with the smallest SCS among the carrier(s) applying the beam indication.

Table 6 Additional inputs: issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 5**  **2) Share your inputs on the above FL proposals** |
| MediaTek | Support Proposal 3.A.  We have concern on Alt2 and Alt3.   * Concern on Alt2: May cause unnecessary latency compared with Alt1 when the CC carrying the ACK of the beam indication has the smallest SCS but it is not one of the CCs applying the new beam. This case can happen in FR1+FR2 CA where PUCCH cell is usually configured in FR1 with much smaller SCS compared with the CCs in FR2, thus larger additional latency. * Concern on Alt3: Alt3 cannot guarantee that the switching timing always occurs at the slot boundary if the CC carrying the ACK of the beam indication has SCS larger than the SCS(s) of CC(s) applying the new beam.   On Issue 3.4: We see a potential issue may happen during the transition time between TCI activation and a DCI indicates a TCI state from the new activated TCI list. During the transition time, if the currently applied TCI state is not in the new activated TCI list, UE needs to track on one more TCI states (M TCI states in the list + 1 currently applied TCI state) before a DCI indicates a TCI state from the new activated TCI list.  In order to avoid this, the activated TCI state(s) for the lowest codepoint is/are applied until a beam indication DCI is received when more than one TCI codepoints are activated by MAC CE and the currently applied TCI state(s) is not in the new active TCI list. |
| NTT Docomo | Proposal 3.A: Support. We think issue 3.2 can be discussed separately.  On Issue 3.3, we don’t understand the discussion point. As the agreement below, indicated beam is updated after the acknowledgment (ACK). There is no agreement that Y-symbol is counted from ACK/NACK. So, “***only ACK can be used to confirm beam indication*”** is already agreed.  **Agreement**  On Rel-17 DCI-based beam indication, regarding application time of the beam indication, the first slot to apply the indicated TCI is at least Y symbols after the last symbol of the acknowledgment of the joint or separate DL/UL beam indication.   * Note: The Y symbols are configured by the gNB based on UE capability, which is also reported in units of symbols. * FFS whether Y is configured per BWP , per CC or per band or per SCS , or independent of BWP/CC/SCS   + Note: Previous agreement in RAN1#104b-e that remaining unused DCI fields and codepoints are reserved in R17 are not to be reverted   Issue 3.4: we think group common beam indication is beneficial to reduce DCI transmission to multiple UEs.  Also, when MAC CE indicates multiple active TCI states, beam indication DCI can select one of the active TCI states. How to determine the QCL assumption of the beam indication DCI should be discussed (e.g. previous common beam, or the lowest TCI codepoint). |
| Qualcomm | For 3.A, support, this option requires the minimum application time, which is dynamically determined based on all applied SCSs. Considering ACK SCS may unnecessarily increase the application time. |
| Samsung | **Proposal 3.A:** For progress we can accept as this is the majority view. But we would like to point out that the general principle since NR Rel-15 to determine latency has been to base this on the SCS of the channel carrying the indication as well as the channel to which the indication is being applied. For example, to determine the processing latency for HARQ-ACK feedback, this not only depends on the SCS of the HARQ-ACK feedback carrying channel, but also on the SCS of the corresponding PDCCH and PDSCH … this is an example from 38.214 (section 5.3):  *N1* is based on *µ* of table 5.3-1 and table 5.3-2 for UE processing capability 1 and 2 respectively, where *µ* corresponds to the one of (*µPDCCH*, *µPDSCH*, *µUL*) resulting with the largest *Tproc,1*, where the *µPDCCH* corresponds to the subcarrier spacing of the PDCCH scheduling the PDSCH, the *µPDSCH* corresponds to the subcarrier spacing of the scheduled PDSCH, and *µUL* corresponds to the subcarrier spacing of the uplink channel with which the HARQ-ACK is to be transmitted, and κ is defined in subclause 4.1 of [4, TS 38.211].  The rationale for this is when the UE is receiving/transmitting the channel triggering the processing (in this case the HARQ-ACK with positive feedback to trigger beam switching) its processing timing could be based on the SCS of that channel. Typically, the smaller SCS has the longer processing delay.  **Issue 3.4:** While we were strongly supportive of some of the features mentioned in this category, unfortunately it is too late at this stage. We still have a number of pressing issues to resolve and issue 3.4 is not one of them. |
| 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? |

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

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   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. |
| 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~~ |
| 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. |
| 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** |

### 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  **No**: vivo (include panel ID) |
| 5.2 | Supported value(s) of N and M | Supported value(s) of N:   * **{1}**: Ericsson * **#beams {1,2,3,4 + UE cap}** (same as Rel-15/16 beam reporting): ZTE, Samsung, Sony, Nokia/NSB, Qualcomm, MTK * **Other** (specify):   + **#panels (2,3, or depends on UE cap)**: Spreadtrum, Lenovo/MotM, CATT, Xiaomi, LG   Supported value(s) of M:   * **Only 1**: ZTE, Samsung, Ericsson, CATT, Intel, NTT Docomo, Sony, Nokia/NSB, Apple, LG, Qualcomm, MTK, 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 |
| 5.4 | Beam vs panel level | **Beam**: IDC, Sony, Nokia/NSB, Qualcomm, MTK, Convida  **Panel**: Huawei/HiSi, Spreadtrum, vivo, Lenovo/MotM, CATT, LG  **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 at least N=1

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

Table 10 Additional inputs: issue 5

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

Table 11 Summary: issue 6

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

# 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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