**3GPP TSG RAN WG1 #105-e R1-2105290**

**e-Meeting, May 10th – 27th, 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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| * Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:   + Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management to support higher intra- and L1/L2-centric inter-cell mobility and/or a larger number of configured TCI states:     1. Common beam for data and control transmission/reception for DL and UL, especially for intra-band CA     2. Unified TCI framework for DL and UL beam indication     3. Enhancement on signaling mechanisms for the above features to improve latency and efficiency with more usage of dynamic control signaling (as opposed to RRC)   + Identify and specify features to facilitate UL beam selection for UEs equipped with multiple panels, considering UL coverage loss mitigation due to MPE, based on UL beam indication with the unified TCI framework for UL fast panel selection |

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 | For QCL-Type D configuration in TCI state(s) shared across a set of CCs (that is associated with the same gNB beam):   * **Alt1**: Separate QCL-Type D RS for each of the CCs can be determined from the TCI state(s). The determined QCL-Type D RSs for the set of CCs are further associated with a same QCL-Type D RS. * **Alt2**: A single QCL-Type D RS for the set of the CCs is determined from the TCI state(s), and support enhanced QCL chain:   + **Alt.2-1**: Support Opt. A only.   + **Alt.2-2**: Support Opt. B only.   + **Alt.2-3**: Support both Opt. A and Opt. B.   Options of the enhanced QCL chain:   * Opt. A: The QCL-Type A TRS and, if any, QCL-Type D CSI-RS, with different CSI-RS resources. * Opt. B: The QCL-Type A TRS and, if any, QCL-Type D SSB. | **Alt 1**: Nokia/NSB, CATT, Apple, Sony, NTT Docomo, Intel, LG, APT/FGI, Ericsson  **Alt 2-1**: OPPO, MTK (2nd)  **Alt 2-2**:  **Alt 2-3**: vivo, Samsung, ZTE, Qualcomm, MTK (1st) |
| 1.2 | Setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index):   * AltA. The setting of (P0, alpha, closed loop index) is also associated with UL or (if applicable) joint TCI state * AltB. The setting of (P0, alpha, closed loop index) is also included with UL or (if applicable) joint TCI state * AltC. The setting of (P0, alpha, closed loop index) is neither associated with nor included in UL or (if applicable) joint TCI state   Note: It has been agreed that the setting of (P0, alpha, closed loop index) is associated with UL channel or UL RS (therefore the setting is channel- and signal-specific). | **AltA**: Lenovo/MoM, Spreadtrum, CMCC (PUSCH/PUCCH), Nokia/NSB, Futurewei, Fraunhofer IIS/HHI, ZTE, CATT (MAC CE update), OPPO (PUSCH, PUCCH), Apple, NTT Docomo, MTK, Intel (2nd preference)  **AltB**: Nokia/NSB, Samsung, IDC, Apple, Qualcomm, NTT Docomo (2nd pref), LG, Intel  **AltC**: vivo, Ericsson (P0 and alpha), Huawei, HiSi, OPPO (SRS, per resource set), Sony |
| 1.3 | Path-loss measurement (PL RS):   * AltA. PL-RS can be included in UL TCI state (or, if applicable, joint TCI state). * AltB. PL-RS can be associated with (but not included in) UL TCI state (or, if applicable, joint TCI state)   + FFS: Exact association mechanism * AltC. UE calculates path-loss based on periodic DL RS configured as the source RS for determining spatial TX filter in UL or (if applicable) joint TCI state   + FFS: If a PL RS is not included in or associated with the UL TCI state (or, if applicable, joint TCI state), whether the UE can estimate path-loss based on the PL-RS of an UL RS provided in an UL TCI state (or, if applicable, joint TCI state) as a source RS for determining the spatial TX filter. | **AltA**: Nokia/NSB, Ericsson, IDC, Fraunhofer IIS/HHI, Samsung (2nd preference), OPPO, Qualcomm, AT&T, NTT Docomo, LG, Intel  **AltB**: Lenovo/MoM, Spreadtrum, CMCC, Futurewei, ZTE, CATT (MAC CE update), Huawei, HiSi, Sony, MTK  **AltC**: vivo, Nokia/NSB (if not configured in TCI state), Samsung, ZTE (if not configured in TCI state), Apple, Ericsson  **One solution only** (no mixture optional/default): NTT Docomo, , Samsung, Qualcomm |
| 1.4 | See table below (cf. offline discussion [1])  Do the following ‘other signal(s)/channel(s)’ admit Interpretation 1 when operating with Rel-17 unified TCI? | CSI-RS resource for CSI:   * **Yes**: Lenovo/MoM, Spreadtrum, Nokia, Ericsson, Samsung, Fraunhofer IIS/HHI, ZTE (only AP), OPPO, Apple (at least AP), Convida, APT/FGI, Xiaomi, CATT * **No**: vivo, Huawei, HiSi   Some CSI-RS resource(s) for BM (if so, which one(s), e.g. aperiodic, repetition ‘ON’)   * **Yes**: Nokia/NSB, Ericsson, Samsung, Fraunhofer IIS/HHI (rep ON), OPPO (one resource with rep ON), Apple (at least AP), APT/FGI (rep ON), ZTE (only AP), Xiaomi, CATT * **No**: vivo, Spreadtrum, Huawei, HiSi   CSI-RS for tracking:   * **Yes**: Lenovo/MoM, Ericsson * **No**: vivo, Spreadtrum, Samsung, Huawei, HiSi, MTK, ZTE     Some SRS resources or resource sets for BM:   * **Yes**: Ericsson, OPPO, ZTE, APT/FGI * **No**: Huawei, HiSi   Non-UE-dedicated reception on PDSCH and all/subset of CORESETs:   * **Yes**: vivo * **No**: Huawei, HiSi |
| 1.5 | See table below (cf. offline discussion [1])  For ‘other signal(s)/channel(s)’ which do not admit Interpretation 1 when operating with Rel-17 unified TCI (i.e. only Interpretation 2 is applicable), what TCI state update/configuration mechanism is used? | **Rel-15/16 update/configuration mechanism**: Fraunhofer IIS/HHI, Samsung, OPPO, ZTE, MTK  **Rel-17 update/configuration mechanism (using M>1 or N>1)**: vivo |
| 1.6 | For separate TCI, UL TCI state pool  Alt1: Shared pool with joint/DL TCI state  Alt2: Separate pool | **Alt1**: vivo, Spreadtrum, Samsung, Xiaomi, ZTE, Qualcomm, MTK, Convida, NTT Docomo, Intel  **Alt2**: CMCC, Ericsson, Futurewei, Huawei, HiSi, Fraunhofer IIS/HHI, OPPO |
| 1.7 | TCI state pool for CA  Alt1: Separate, per CC  Alt2: Shared among all CCs  Note: This is related to 1.1. | **Alt1:** Nokia/NSB, Huawei, HiSi, OPPO, LG, Ericsson, CATT  **Alt2:** vivo, Spreadtrum, Apple, Samsung, Xiaomi, Sony, Qualcomm, NTT Docomo, MTK, Intel, ZTE |
| 1.8 | Maximum value of M (DL) and N (UL) along with the use case(s) | Max M:   * **1 for sTRP**: Spreadtrum, ZTE, Samsung, Convida, NTT Docomo, MTK, OPPO, Ericsson * **>1 only for mTRP**: Samsung (M=2), Apple (M=2), LG, OPPO (M = 2) * **>1 for uses other than mTRP (specify)**: Futurewei, CATT, Qualcomm, LG   Max N:   * **1 for sTRP**: Spreadtrum, ZTE, Samsung, Convida, NTT Docomo, MTK, OPPO, Ericsson * **>1 only for mTRP/panel**: Samsung (N=2), Apple (N=2), LG, OPPO (N = 2) * **>1 for uses other than mTRP (specify)**: Futurewei, CATT, Qualcomm, LG |
| 1.9 | If M>1 and/or N>1 are supported, whether this implies simultaneous reception with different DL QCL(s) or transmission with different UL spatial filter(s) | **Yes**: Apple  **No**: |
| 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:** vivo, Samsung, ZTE, MTK, NTT Docomo, Xiaomi * **No:** Spreadtrum, OPPO, Apple, Intel, APT/FGI   SRS for BM, optionally with TRS as QCL Type-A source RS   * **Yes:** vivo, Spreadtrum, Nokia/NSB, Samsung, IDC, ZTE, Convida, Xiaomi * **No:** Ericsson, Fraunhofer IIS/HHI, OPPO, LG, APT/FGI   CSI-RS for CSI   * **Yes:** CMCC, ZTE, Sony * **No:** vivo, Spreadtrum, Samsung, OPPO, APT/FGI |
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**From offline discussion on how Rel-17 unified TCI applies to ‘other signals/channels’ (1-4 and 1-5):**

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| For discussion purposes, the term ‘other signal(s)/channel(s)’ refers to channel(s), CORESET(s), or a signal(s) *other than* (DL) UE-dedicated reception on PDSCH and all/subset of CORESETs), as well as (UL) dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources. That is:   * For DL: CSI-RS resource for CSI, some CSI-RS resource(s) for BM, CSI-RS for tracking, non-UE-dedicated reception on PDSCH and all/subset of CORESETs * For UL: Some SRS resources or resource sets for BM   Two possible interpretations on how Rel-17 unified TCI applies to ‘other signal(s)/channel(s)’. We use CSI-RS resource for CSI as an example to illustrate the point.   * Interpretation 1: The CSI-RS resource for CSI shares the same (Rel-17 DL or, if applicable, joint) TCI state machine (hence ‘DL RX beam tracking loop’) as that for UE-dedicated reception on PDSCH and all/subset of CORESETs. This works regardless of the values of M and/or N.   + In this case, the Rel-17 DL or, if applicable, joint TCI state used for the CSI-RS resource for CSI needs to be associated with some UE-dedicated reception on PDSCH and all/subset of CORESETs. * Interpretation 2: The CSI-RS resource for CSI uses a different (Rel-17 DL or, if applicable, joint) TCI state machine (hence ‘DL RX beam tracking loop’) as that for UE-dedicated reception on PDSCH and all/subset of CORESETs. This [may] require M>1 and/or N>1 [if Rel-17 TCI state update/configuration mechanism is used].   + In this case, a separate Rel-17 DL or, if applicable, joint TCI state dedicated to the CSI-RS resource for CSI can be used without any association with any UE-dedicated reception on PDSCH and all/subset of CORESETs. |

The following observation can be made:

* (1.2, 1.3) These two issues have bene discussed since RAN1#103-e (11/2021) and need to be concluded. Preferences from companies do not change significantly although they are better understood. In general, a number of companies prefer not to support two-scheme (default/optional) solutions as those would impose complication on both NW and UE implementation.
  + On PL-RS, detailed aspects of the PL-RS can be further discussed after proposal 1.2 is agreed.
* (1.1/1.7) From offline discussion [1], proposals 1.3 (on CA QCL) is a good compromise between Alt1 and Alt2 proponents (Alt1 represents slight majority view).
* (1.4, 1.5) From offline discussion [1], proposals 1.4 (on applicability and use of Rel-17 TCI states) may be agreed after some discussion. Proposal 1.5 and 1.6 are good starting points for finalizing the issue in this meeting.
* (1.10) The situation has not changed since RAN1#103-e. It is time to conclude.

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

**Proposal 1.1**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, the setting is included in UL TCI state or (if applicable) joint TCI state or associated with index/codepoint of UL TCI state or (if applicable) joint TCI state.

* Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed and the signaling) is up to RAN2

**Proposal 1.2**: On path-loss measurement for Rel.17 unified TCI framework, a PL-RS (configured for path-loss calculation) is included in UL TCI state or (if applicable) joint TCI state or associated with index/codepoint of UL TCI state or (if applicable) joint TCI state.

* If the DL source RS in the UL or (if applicable) joint TCI state to provide spatial relation indication is different from PL-RS, the choice of RS for path-loss measurement (either the DL source RS in the TCI state or the PL-RS) is up to the UE
* Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed and the signaling) is up to RAN2
* The UE maintains the PL-RS of the activated UL TCI state or (if applicable) joint TCI state
* The maximum number of active UL TCI states or (if applicable) joint TCI states per band is a UE capability
* FFS: detailed aspects of PL-RS, e.g. CSI-RS type(s), time-domain behavior(s), restriction on configuration

**Proposal 1.3A**: On Rel.17 unified TCI framework, [a single RRC pool of TCI states is used] for 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/BWPs

* A CC~~-~~specific source RS can be determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter. The determined CC-specific source RSs for the set of configured CCs/BWPs are further associated with a same QCL-TypeD RS.
  + Note: From a previous agreement, the common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs/BWPs
  + [FFS: how to provide the CC/BWP-specific RSs in a TCI state of the single RRC TCI state pool shared among the set of configured CCs/BWPs, e.g., the BWP/CC ID for the source RS for QCL Type-D reference and/or UL TX spatial reference can be absent in a TCI state]
* “A set of configured CCs/BWPs” includes all the BWPs in the set of configured CCs in one band

**V.S.**

**Proposal 1.3B:** On Rel.17 unified TCI framework, [a single RRC pool of TCI states is used] for 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/BWPs

* A single QCL-Type D RS for the set of configured CCs/BWPs is determined from the TCI state(s)
  + The following Rel-15/16 QCL rule is used: The QCL-Type A TRS and, if any, QCL-Type D CSI-RS with higher-layer parameter ‘repetition’ configured, with different CSI-RS resources
* “A set of configured CCs/BWPs” includes all the BWPs in the set of configured CCs in one band

**Proposal 1.4**: On Rel.17 unified TCI framework,

* Any DL RS or DL physical channel that is a valid target signal/channel of a Rel-15/16 TCI state and spatial relation based on the Rel-15/16 QCL rules can be configured as a target signal/channel of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool)
* FFS: Whether some SRS resources or resource sets for BM can be configured as a target signal/channel of a Rel-17 UL TCI (hence the Rel-17 UL TCI state pool)

**Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#105-e, discuss and decide

* Whether each of the following DL RSs and channels can share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC
  + CSI-RS resources for CSI
  + Some CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)
  + CSI-RS for tracking
  + Non-UE-dedicated reception on PDSCH and all/subset of CORESETs
  + For M>1, subset of UE-dedicated CORESETs
  + For N>1, subset of UE-dedicated PUCCH resources
* Whether some SRS resources or resource sets for BM can share the same Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC

**Proposal 1.6**: On Rel.17 unified TCI framework, for the following (‘other’) signal/physical channel:

* Any DL RS or DL physical channel that does not share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC
* Any UL RS or UL physical channel that does not share the same Rel-17 TCI state dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC,

Discuss and down-select in RAN1#105-e between the following two alternatives:

* Alt1. Rel-15/16 TCI state and, if applicable, UL spatial relation update signaling/configuration mechanism(s) are reused to update/configure the Rel-17 TCI state
* Alt2. New TCI state update signaling/configuration mechanism(s) are used, e.g. with Rel-17 MAC-CE/DCI-based beam indication for Rel-17 joint/separate TCI

Note: For some channels/signals, only one of the above two alternatives may apply (to be discussed).

**Conclusion 1.7**: On Rel.17 unified TCI framework, in RAN1#105-e, there is no consensus on supporting the following source RS types for DL QCL Type-D reference for DL common UE-dedicated reception on PDSCH and all/subset of CORESETs:

* SSB
* SRS for BM
* CSI-RS for CSI

Table 2 Additional inputs: issue 1

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 1**  **2) Share your inputs on the above FL proposals** |
| MediaTek | P1.1 and P1.2: Support. We would like to further check whether the signaling (RRC or MAC-CE) to provide the association is also decided by RAN2 if ‘associated with’ is adopted by RAN2. If so, we prefer to further clarify it in the proposal. For example,   * Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed and the signaling) is up to RAN2   P1.3: We can support the proposal if the brackets of [a single RRC pool of TCI states is used] are removed. Regarding how to provide the “CC-specific” RSs in a TCI state for multiple CCs, the BWP/CC ID for the source RS can be absent in a TCI state, and RS will be located in the active BWP in each CC by default.  [Mod: Based on the current situation, we may need to consider two versions of the proposals based on Alt1 vs Alt2.1 – to be discussed in later rounds]  P1.4: We prefer not to introduce any new signaling mechanism for “other” signals/channels not applying Rel-17 TCI state machine. However, it may not be possible to reuse Rel-15/16 UL spatial relation update signaling/configuration mechanism(s) to update/configure the Rel-17 TCI state for “other” UL signals/channels not applying Rel-17 TCI state machine. Since RS index is directly provided as spatial relation, it is quite different from TCI state. Thus, for UL part in P1.4, we prefer to leave it for further study.  [Mod: Done, same comment as OPPO – it seems the only UL signal of interest is “some SRS for BM”]  P1.5: Support  P1.6: For Alt1, as mentioned above, we see it may not be possible to reuse Rel-15/16 UL spatial relation update signaling/configuration mechanism(s) to update/configure the Rel-17 TCI state for “other” UL signals/channels not applying Rel-17 TCI state machine.  [Mod: Agree. Let’s discuss this to refine the proposal in later rounds. I added a note which should resolve your concern.]  P1.7: Support |
| Nokia/NSB | Proposal 1.1  Open for further discussion  Proposal 1.2  Not support subbullets. We don’t think PL measurement can depend on UE implementation. It should be clarified in the spec. We can only accept the main bullet only.  And for the clarification, in our understanding, when we say association to TCI state, we may consider association to the TCI index not to the TCI state itself. Can we confirm the general understanding?  **Proposal 1.2**: On path-loss measurement for Rel.17 unified TCI framework, a PL-RS (configured for path-loss calculation) is either included in TCI state or associated with index/codepoint of UL TCI state or (if applicable) joint TCI state.   * ~~If the DL RS in the UL or (if applicable) joint TCI state to provide spatial relation indication is different from PL-RS, path-loss measurement is up to UE implementation~~ * ~~Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed) is up to RAN2~~ * ~~FFS: detailed aspects of PL-RS, e.g. CSI-RS type(s), time-domain behavior(s), restriction on configuration~~   [Mod: Please see revised version which should address your concern]  Proposal 1.3: We slightly prefer separated TCI pool per CC, but can be open for further discussion.  Proposal 1.4: Support  Proposal 1.5: Support  Proposal 1.6: Support |
| Intel | Proposal 1.1: OK. Also OK with Mediatek’s clarification  Proposal 1.2: OK with the main bullet and 2nd sub-bullet. Share Nokia’s concern on UE implementation based PL measurement. Would be good have further discussion on this case. We can keep it as FFS for now.  [Mod: Please see revised version which should address your concern]  Proposal 1.3: OK in principle.  Proposal 1.4 – 1.6: Our general preference is to implement a clean design of Rel-17 unified TCI framework which replaces the spatial relation information signaling from Rel-15/16. To this end, leaving some configurations to re-use old framework while some use the new framework is not preferable. The two frameworks should not co-exist down the road making the whole design more complicated. As a result, in Proposal 1.6, we are not sure how Alt.1 works, especially since the Rel-17 UL TCI state definition and contents are not finalized yet.  [Mod: That is indeed the goal. Re proposal 1.6, this will be discussed further. For now, we need to shape the discussion with proposal 1.6. Also added a note per your concern (similar to MTK)] |
| Qualcomm | For Proposal 1.1, Suggest the following wording for potential RRC+MAC-CE based PL RS update, similar to R16  **Proposal 1.1**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, the setting is ~~either~~ included in and/or associated with UL TCI state or (if applicable) joint TCI state.   * Whether it is ‘included in’, ~~or~~ ‘associated with’ (including the manner it is performed), or both (e.g. MAC-CE updates the one configured in TCI state) is up to RAN2   [Mod: The current wording should be ok. We do not touch the RRC vs MAC CE issue here. It is left to RAN2 (an LS will be sent). But to accommodate your input, I have removed “either” and that should be enough]  For Proposal 1.2, same wording suggestion  **Proposal 1.2**: On path-loss measurement for Rel.17 unified TCI framework, a PL-RS (configured for path-loss calculation) is ~~either~~ included in and/or associated with UL TCI state or (if applicable) joint TCI state.   * If theDL RS in the UL or (if applicable) joint TCI state to provide spatial relation indication is different from PL-RS, path-loss measurement is up to UE implementation * Whether it is ‘included in’, ~~or~~ ‘associated with’ (including the manner it is performed), or both (e.g. MAC-CE updates the one configured in TCI state) is up to RAN2 * FFS: detailed aspects of PL-RS, e.g. CSI-RS type(s), time-domain behavior(s), restriction on configuration   [Mod: Please see above]  For Proposal 1.3, suggest the following wording for the following reasons:   * I guess the bracket in the main bullet is because one or multiple pools is still FFS. So suggest to reword the main bullet and add the FFS as a sub-bullet; * Common TCI state ID may or may not provide common beam in R16. So suggest to remove it from main bullet; * Modified the original 1st sub-bullet to emphasize at least a single common beam indication RS can be indicated for all BWPs/CCs; I guess that is the intention. * Removed the bracket for FFS and clarify that it is for the case each BWP/CC has its own source RS, especially for TypeA RS, which must be different for different BWP/CC   **Proposal 1.3**: On Rel.17 unified TCI framework, ~~[a single RRC pool of TCI states is used]~~ each configured RRC pool of TCI states is used for 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/BWPs   * FFS: whether a single or multiple RRC pools can be configured across a set of configured CCs/BWPs * At least a common ~~A CC-specific~~ source RS can be determined from the indicated common TCI state ID to provide common QCL Type-D indication and/or to determine common UL TX spatial filter across the set of configured CCs/BWPs. ~~The determined CC-specific source RSs for the set of configured CCs/BWPs are further associated with a same QCL-TypeD RS.~~   + […]   + ~~[~~FFS: how to provide the CC/BWP-specific source RSs from ~~in~~ a TCI state of one ~~the single~~ RRC TCI state pool shared among the set of configured CCs/BWPs, e.g., the BWP/CC ID for the source RS for QCL Type-A/D reference and/or UL TX spatial reference can be absent in a TCI state~~]~~ * […]   [Mod: See latest version]  For Proposal 1.4, suggest the following wording to include joint TCI  **Proposal 1.4**: On Rel.17 unified TCI framework,   * Any DL RS or DL physical channel that is a valid target signal/channel within the Rel-15/16 QCL rules can be configured as a target signal/channel of a Rel-17 DL or joint TCI (hence the Rel-17 DL and joint TCI state pool(s)) * Any UL RS or UL physical channel that is a valid target signal/channel within the Rel-15/16 UL spatial relation rules can be configured as a target signal/channel of a Rel-17 UL or joint TCI (hence the Rel-17 UL and joint TCI state pool(s))   [Mod: Please check offline discussion comments from Huawei in R1-2105296. This has been discussed. “Joint” is not needed.]  For Proposal 1.5, fine to discuss. Our preference is allow sharing same configured TCI for any RS/channel  For Proposal 1.6, suggest to discuss after Proposal 1.5. Because it would be more efficient to reuse/share same R17 TCI for any DL/UL RS/channel.  [Mod: Intended to set direction for discussion.] |
| Apple | Proposal 1.1: Support  Proposal 1.2: We can compromise to consider PL-RS with one of the additional bullets   * Option 1: Introduce a UE capability to report whether it beam alignment between PL-RS and DL-RS for beam indication * Option 2: Enhance FG 2-4 and 2-62 that PL-RS is counted for active TCI * Option 3: Pathloss measurement is up to UE implementation if beam mismatch happens * Beam alignment/mismatch can be defined based on whether the DL-RS for beam indication and PL-RS is the same or whether there is direct/indirect QCL relationship between DL-RS for beam indication and PL-RS.   We are also fine without any consensus for PL-RS, which means the SSB for MIB decoding would be used.  [Mod: Please check latest version which should address your concern]  Proposal 1.3: OK. We support single TCI state pool, which can save overhead. R15 design unnecessarily requires large UE memory.  Proposal 1.4: As downlink QCL indication is a 2-stage approach, does this mean we need at least 2 types of unified TCI – one for CSI-RS, the other for PDSCH/PDCCH? Similarly uplink spatial relation indication for PUSCH is based on a 2-stage approach, does it mean SRS for CB/NCB can be included in UL TCI, and there would be two types of UL TCI – one for SRS/PUCCH, the other for PUSCH?  [Mod: If CSI-RS can use Rel-17 TCI and if it does not share the same TCI state as PDSCH/PDCCH, it means we have two Rel-17 TCI states which share the SAME.COMMON DL TCI pool: one for PDSCH/PDCCH, the other for CSI-RS. Then the next question is signaling mechanism (proposal 1.6).  But if CSI-RS shares the same TCI state as PDSCH/PDCCH (currently majority view), there is only one Rel-17 TCI state.]  Proposal 1.5: Support in principle.  Proposal 1.6: We suggest we first identify what “other signal/channel” is, and decide the solution later.  Proposal 1.7: Support |
| Samsung | Proposal 1.1: Support  Proposal 1.2: We share Apple’s view that the PL RS and the beam RS should be aligned to the same QCL source. However, the current wording of the first sub-bullet seems to imply that the PL RS and beam RS should be the same. We suggest the following update:  “A UE expects that the DL RS in the UL or (if applicable) joint TCI state providing spatial relation indication and the PL-RS are aligned to the same QCL source”.  [Mod: Please check latest version which should address your concern]  Proposal 1.3: We agree with the direction of the proposal as a compromise, but we would like to remove the square brackets around “a single RRC pool of TCI states is used”  Proposal 1.4: Support with a small wording update   * Any DL RS or DL physical channel that is a valid target signal/channel ~~within the~~ of a Rel-15/16 TCI state QCL rules can be configured as a target signal/channel of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool)   [Mod: Done]  Proposal 1.5: Support  Proposal 1.6: Support slight preference for Alt1, as we have limited TCI state indication capability in release 17 (with no repurposing) |
| OPPO | Proposal 1.1: Only support it for PUSCH and PUCCH. But not support it for SRS. For SRS, the (P0, alpha, closed loop index) shall be configured to the set and they shall not change along with the TCI state switch  [Mod: Noted. Since the majority supports this proposal, it is kept as is for now.]  Proposal 1.2: Support  Proposal 1.3: The proposal contradict with the previous agreement. In previous agreement, the QCL-TypeRS is a “same/single RS”. But this proposal proposes to use CC-specific RS, which are definitely not same/single RS. The reason for agreed “same/single RS” is to ensure same beam on those CC. The new description of “CC-specific source RS… with a same QCL-TypeD RS” can not ensure the same beam on multiple CCs because from the perspective of PDCCH and PDSCH, only the indirect QCL is same and that does not mean same beam.  [Mod: It doesn’t contradict since it uses indirect QCL. But I added 1.3B to see which one can be agreed – to be discussed in the next rounds]  Proposal 1.4: The proposal is confusing. For example, regarding the SRS of BM, does the proposal mean that we are going to just replace the “spatial relation info” with ‘TCI state’ but still use the beam indication control signaling specified in rel15/16? If so, why we bother to repeat the same function here? If not so, does the proposal mean the indicated “common TCI” in rel17 unfied TCI framework will be applied to all the channel and reference signals?  [Mod: Please check revised version which should address your concern.]  Proposal 1.5: Ok  Proposal 1.6: For ‘other signal/channels’: we suggest to reuse whatever is specified in rel15 and rel16 and do not repeat the same function by replacing “spatial relation info” with “UL TCI”.  [Mod: Next step discussion☺]  Conclusion 1.7: Ok |
| ZTE | Proposal 1.1: Support. We are also fine with MTK’s or QC’s clarification.  Proposal 1.2: Support  Proposal 1.3: As we mentioned before as in offline discussion, it is a compromise solution that the Alt1 + a single RRC pool, and the bracket for a single RRC pool should be removed. Otherwise, we need to go Alt2, and to be honest, we do believe that Alt1 is to revert the previous agreement.   * **Alt1**: Separate QCL-Type D RS for each of the CCs can be determined from the TCI state(s). The determined QCL-Type D RSs for the set of CCs are further associated with a same QCL-Type D RS. * **Alt2**: A single QCL-Type D RS for the set of the CCs is determined from the TCI state(s), and support enhanced QCL chain:   [Mod: Done. Actually for Alt2.1, the QCL rule is already supported in Rel-15/16 in my understanding]  Proposal 1.4: A little bit confusing. If our understanding is correct, we only need to clarify which types RSs/channels can be assumed as target ones of unified TCI framework in the spec, and if unified TCI framework is enabled, then the UE need to follow the specified UE behavior corresponding unified TCI framework rather than Rel-15/16. If so, it seems that this proposal is not needed unless we would like to clarify some ambiguities among companies.  [Mod: Please check the latest version, also offline discussion in R1-2105296. This proposal was made per comment from Huawei.]  Proposal 1.5: Support. Our preference can be found in the above tables.  Proposal 1.6: Support.  Proposal 1.7: Considering that we already supported that CSI-RS for CSI can be configured as source RS in Rel-15/16 QCL chain, we slightly prefer to keep CSI-RS for CSI as source RS in Rel-17 unified TCI framework also.  [Mod: Understood but there is no consensus on this.] |
| LG | Proposal 1.1: Support  Proposal 1.2: Support the main bullet but we share a similar view with Nokia on the first sub-bullet that it needs further discussion for how to handle the case.  [Mod: please check revised version]  Proposal 1.3: It is preferred to remove ‘a single RRC pool of TCI state is used’ in main bullet and discuss further on that as FFS. As Huawei and CATT mentioned in offline discussion, it would lead the same UL PC across CCs by taking PC setting included in/associated with UL TCI into account.  [Mod: Now it is back to two alternatives. We will discuss next rounds since there seems no hope to converge on this early.]  Proposal 1.4, 1.5, 1.6 and Conclusion 1.7: Support |
| Xiaomi | Proposal 1.1, support.  Proposal 1.2, for the first sub-bullet, we think it need to be specified when the DL RS in the UL or (if applicable) joint TCI state to provide spatial relation indication is different from PL-RS.  [Mod: This would restrict NW implementation, and could potentially need a new test case in RAN4, and most likely not agreeable. Note that this is the way it is handled in Rel-15/16 (left to UE)]  Proposal 1.3, support.  Proposal 1.4, support. And fine with the revision from Qualcomm.  Proposal 1.5, support.  Proposal 1.6, it is not clear how to reuse UL spatial relation update signaling/configuration mechanism(s) to update/configure the Rel-17 TCI state. It is better to discuss it after the definition of UL TCI state or joint TCI state is completed.  [Mod: Next step discussion. Signaling mechanism and TCI state/pool are two separate issues] |
| NTT Docomo | Support proposal 1.1~1.6.  On proposal 1.6, we prefer Alt.1. |
| Fraunhofer IIS/HHI | Proposal 1.1: Agree in principle.  Proposal 1.2: Support the main bullet in principle. We’d prefer that in certain scenarios that the indication of the PL RS along with the TCI state is optional to lower the control information overhead (PL RS is a periodic DL RS indicated as a spatial source or PL RS is the one used for the UL RS indicated as spatial source in the TCI state) as lowering the overhead and improving latency is also a target for this work item.  [Mod: A number of companies have concern on two-scheme solution resulting from optionality]  Proposal 1.4, 1.5 and 1.6: Proposal 1.5 and 1.6 seem to address the relevant issues concerned with target channels and signals for unified TCI and the signaling mechanisms to be used for the ones left out. Proposal 1.4 seems somewhat contradictory to proposal 1.5. Proposal 1.5 says that “decide whether each of the following DL/UL RSs and channels can share the same Rel-17 TCI state” and proposal 1.4 says “Any DL RS or DL physical channel (or UL RS or UL channel) that is a valid target signal/channel within the Rel-15/16 QCL rules can be configured as a target signal/channel.” This conflicting message can be avoided if we keep only one of them. In our opinion, proposal 1.5 is good enough and 1.4 is not required.  [Mod: If you closely follow offline discussion in R1-2105296, there should not be any confusion. A signal can be a target for Rel-17 TCI state but doesn’t have to share the SAME Rel-17 TCI state as PDSCH/PDCCH – or PUSCH/PUCCH. This implies there are >1 Rel-17 TCI states even if those different Rel-17 TCI states share the same TCI state pool.]  Conclusion 1.7: Support |
| CATT | Proposal 1.1: One minor wording suggestion below  On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, the setting is either included in UL TCI state or (if applicable) joint TCI state or associated with index/codepoint of UL TCI state or (if applicable) joint TCI state.  [Mod: Done]  Proposal 1.2: On the main bullet, sharing same view as Nokia on the following wording changes:  On path-loss measurement for Rel.17 unified TCI framework, a PL-RS (configured for path-loss calculation) is either included in UL TCI state or (if applicable) joint TCI state or associated with index/codepoint of UL TCI state or (if applicable) joint TCI state.  [Mod: Done]  Proposal 1.3: OK with the proposal  Proposal 1.4: Support  Proposal 1.5: Support  Proposal 1.6: Support |
| Mod V16 | Revised proposals to address the above inputs. Added proposal 1.3B as an alternative to 1.3A (original) for further discussion.  **Please check the latest version of FL proposals** |
| vivo | Regarding proposal 1.1, we still believe Alt C is the best solution. We don’t understand the motivation to associate the PC parameters with TCI. We don’t even need any agreement on this.  [Mod: The proposal reflects the majority view of having beam-dependent setting in addition to channel/signal-dependent setting. It was agreed in RAN1#104b-e to finalize this issue in this meeting. So we need a conclusion. But if you mean that if no consensus on this issue is needed for a functional design, it is true. If no consensus, AltC is the automatic outcome.]    Regarding proposal 1.2, it is obvious that current formulation would create spec wholes. We would like to start from the AltC formulation. As also commented by other companies, without any agreement, the specification is still working well since the default mode can still be used.  [Mod: The proposal reflects the majority view of explicitly configuring a PL-RS (vs. using periodic DL-RS in the UL TCI). There is no default mode agreed for PL-RS as of now and a number of companies voiced concern on the two-scheme solution. Without any agreement, there is no PL-RS support for Rel-17 unified TCI – the natural outcome would be to use SSB of MBI or leave path-loss measurement up to the UE.]  Regarding CC-specific RS proposal 1.3A, is it correct understanding that UE TCI state ID is still interpreted per BWP (i.e., the QCL-A RS is BWP specific), but the QCL-D RS in the TCI state is CC-specific? Or the QCL-A RS and QCL-D are both CC-specific? If the RS is CC specific, does UE only monitor the part within the active BWP?  **Proposal 1.3A**: On Rel.17 unified TCI framework, [a single RRC pool of TCI states is used] for 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/BWPs   * A CC~~-~~specific source RS can be determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter. The determined CC-specific source RSs for the set of configured CCs/BWPs are further associated with a same QCL-TypeD RS.   + Note: From a previous agreement, the common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs/BWPs   + [FFS: how to provide the CC/BWP-specific RSs in a TCI state of the single RRC TCI state pool shared among the set of configured CCs/BWPs, e.g., the BWP/CC ID for the source RS for QCL Type-D reference and/or UL TX spatial reference can be absent in a TCI state] * “A set of configured CCs/BWPs” includes all the BWPs in the set of configured CCs in one band   [Mod: It is CC-specific and applies to all BWPs in the configured CC. For Type-D RS, however, although it’s is CC-specific, it uses indirect QCL to refer to a same/single RS. The proponents can clarify more]  Regarding proposal 1.4, we are fine with this direction. But the following is restricted to DL.  **Proposal 1.4**: On Rel.17 unified TCI framework,   * Any DL RS or DL physical channel that is a valid target signal/channel of a Rel-15/16 TCI state and spatial relation based on the Rel-15/16 QCL rules can be configured as a target signal/channel of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool) * FFS: Whether some SRS resources or resource sets for BM can be configured as a target signal/channel of a Rel-17 UL TCI (hence the Rel-17 UL TCI state pool)   [Mod: Done]  Regarding proposal 1.5, there is also discussion regarding whether subset of PUCCH needs to share the common beam. Moreover, our understanding is that UE may not be able to differentiate UE dedicated or non-UE dedicated reception for subset of CORESETs.  **Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#105-e, discuss and decide   * Whether each of the following DL RSs and channels can share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC   + CSI-RS resources for CSI   + Some CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)   + CSI-RS for tracking   + Non-UE-dedicated reception on PDSCH   + Subset of CORESETs   + Subset of PUCCH. * Whether some SRS resources or resource sets for BM can share the same Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC   [Mod: Done, note that the above only hold for M>1 and N>1 per the definition concluded in RAN1#104-e]  For proposal 1.6, we would like to understand how Alt.1 legacy spatial relation update signaling is used to reconfigured Rel-17 TCI state. BTW, Alt.2 does not need to be bundled with M>1, N>1.  **Proposal 1.6**: On Rel.17 unified TCI framework, for the following (‘other’) signal/physical channel:   * Any DL RS or DL physical channel that does not share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC * Any UL RS or UL physical channel that does not share the same Rel-17 TCI state dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC,   Discuss and down-select in RAN1#105-e between the following two alternatives:   * Alt1. Rel-15/16 TCI state and, if applicable, UL spatial relation update signaling/configuration mechanism(s) are reused to update/configure the Rel-17 TCI state * Alt2. New TCI state update signaling/configuration mechanism(s) are used, e.g. using M>1 and/or N>1, with Rel-17 MAC-CE/DCI-based beam indication for Rel-17 joint/separate TCI   Note: For some channels/signals, only one of the above two alternatives may apply (to be discussed).  [Mod: Per my previous comments, this is for next step discussion. Agree we can remove M/N]  Regarding conclusion 1.7, we don’t think the conclusion is necessary to be made before we have clear understanding on how the cross carrier beam indication is designed. Moreover, we are open to CSI-RS for CSI that they can be used as the source RS as in Rel-15.  **Conclusion 1.7**: On Rel.17 unified TCI framework, in RAN1#105-e, there is no consensus on supporting the following source RS types for DL QCL Type-D reference for DL common UE-dedicated reception on PDSCH and all/subset of CORESETs:   * SSB * SRS for BM * CSI-RS for CSI   [Mod: Not sure how this is related to cross-carrier beam indication. For SSB, since Alt2-2 is now removed, SSB is irrelevant. SRS is irrelevant for cross-carrier. vivo is open to using CSI-RS for CSI, but more companies view it is not needed. So there is no consensus. The situation has not changed at all from the previous meetings.] |
| APT/FGI | We are generally fine with FL’s proposals/conclusion.  Regarding Proposal 1.1, we may need similar change as Proposal 1.2 as below.   * Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed and the signaling) is up to RAN2   [Mod: Thanks for the good catch! Done!] |
| Samsung2 | For proposal 1.3A/1.3B, we prefer proposal 1.3B.  We would also like to clarify the following, “The following Rel-15/Rel-16 QCL rule is used: The QCL-Type A TRS and, if any, QCL-Type D CSI-RS, with different CSI-RS resources”. According to 38.214, the TRS resources and the QCL Type-D resource should be the same, except for the case of ‘repetition’ for the QCL-TypeD CSI-RS. Is the intention here to restrict this to a CSI-RS with repetition?  [Mod: Yes, configured with the parameter ‘repetition’ which means it is CSI-RS for BM. Added in the proposal to avoid confusion]  *For the DM-RS of PDSCH, the UE shall expect that a TCI-State indicates one of the following quasi co-location type(s):*  *- 'QCL-TypeA' with a CSI-RS resource in a NZP-CSI-RS-ResourceSet configured with higher layer parameter trs-Info and, when applicable, 'QCL-TypeD' with the same CSI-RS resource, or*  *- 'QCL-TypeA' with a CSI-RS resource in a NZP-CSI-RS-ResourceSet configured with higher layer parameter trs-Info and, when applicable, 'QCL-TypeD' with a CSI-RS resource in an NZP-CSI-RS-ResourceSet configured with higher layer parameter repetition,or*  *- QCL-TypeA' with a CSI-RS resource in a NZP-CSI-RS-ResourceSet configured without higher layer parameter trs-Info and without higher layer parameter repetition and, when applicable, 'QCL-TypeD' with the same CSI-RS resource.* |
| Mod V20 | Revised proposals per inputs  **Please check the latest version of FL proposals** |
| NTT Docomo | For proposal 1.3A/1.3B, we support proposal 1.3A.  We have concern on proposal 1.3B, due to the following reasons:   * It makes mandatory for gNB to transmit CSI-RS with repetition. For the gNB who configures QCL-Type A TRS + QCL-Type D TRS, it causes additional RS overhead. * A single QCL-Type D RS has an issue for FR1-FR2 CA. Usually, we don’t configure QCL-Type D RS in FR1. Thus, the single QCL-type D RS cannot be shared in FR1-FR2 CA.   Proposal 1.3A says “*The determined QCL-Type D RSs for the set of CCs are further associated with a same QCL-Type D RS.*” So, it does not contradict with the previous agreement. |
| Lenovo/Motorola Mobility | Proposal 1.1: support  Proposal 1.2: support the main bullet, we cannot support the first bullet. If the DL source RS in the UL TCI is different from the PL-RS, it should not be up to UE to choose the RS for path-loss measurement. The UE shall use the RS specified for PL-RS for path-loss measurement.  Proposal 1.3: between 1.3A and 1.3B we slightly prefer 1.3B.  Proposal 1.4: Support. We want to clarify that this does not imply all DL RS and DL physical channels necessarily share the same TCI.  Proposal 1.5: Support.  Proposal 1.6: Between Alt1 and Alt2, we need to decide separately for different channels and signals.  Proposal 1.7: It is premature to draw this conclusion. We need to decide separately for different RSs during RAN1#105-e meeting. |
| MediaTek | **P1.3:** We still more prefer single TypeD RS in proposal 1.3B. But we can support 1.3A as a compromise only if a single TCI pool is used. Otherwise, we don't see any clear gain from 1.3A compared with Rel-16.  Regarding 1.3B, we share the same view with Docomo is would be restrictive for NW to use only CSI-RS for BM as TypeD source. We prefer to add one more QCL rule TRS for A + other TRS for D. Even thorough this would be a new QCL rule, we don't see much implementation issue on this from UE perspective.   * + The following Rel-15/16 QCL rule ~~is~~ can be used: The QCL-Type A TRS and, if any, QCL-Type D CSI-RS with higher-layer parameter ‘repetition’ configured, with different CSI-RS resources   + Support an additional QCL rule: The QCL-Type A TRS and, if any, QCL-Type D CSI-RS with higher-layer parameter ‘trs-Info’ configured, with different CSI-RS resources   **P1.4:** Regarding the revised proposal with “and spatial relation”, the bullet is only about DL RS or DL physical channel, why spatial relation is added here? We fail to see any DL RS or DL physical channel is a valid target of a spatial relation.  Regarding the TCI pool, since whether separate TCI pools for joint/DL and UL is not decided yet. Thus, we prefer to avoid use the wording. We think “Rel-17 TCI state pool” is clear.  **Proposal 1.4**: On Rel.17 unified TCI framework,   * Any DL RS or DL physical channel that is a valid target signal/channel of a Rel-15/16 TCI state ~~and spatial relation~~ based on the Rel-15/16 QCL rules can be configured as a target signal/channel of a Rel-17 DL TCI (hence the Rel-17 ~~DL~~ TCI state pool) * FFS: Whether some SRS resources or resource sets for BM can be configured as a target signal/channel of a Rel-17 UL TCI (hence the Rel-17 ~~UL~~ TCI state pool)   **P1.5:** Regarding the newly adding sub-bullets for M, N > 1, we suggest to add “if supported” to avoid misunderstanding:   * + For M>1, if supported, subset of UE-dedicated CORESETs   + For N>1, if supported, subset of UE-dedicated PUCCH resources   **P1.6:** If our understanding is correct, P1.6 is discussed based on the conclusions of P1.4 and P1.5. Thus, we prefer adding the following tom make it more clear:  **Proposal 1.6**: On Rel.17 unified TCI framework, for the following (‘other’) signal/physical channel:   * Any DL RS or DL physical channel that does not share the same Rel-17 TCI state 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 signal/channel of a Rel-17 DL TCI (hence the Rel-17 TCI state pool) * Any UL RS or UL physical channel that does not share the same Rel-17 TCI state dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC, but can be configured as a target signal/channel of a Rel-17 UL TCI (hence the Rel-17 TCI state pool) |
| Ericsson | P1.1: Do not support. There is no motivation, except that it was like that in R15/16. Why should P0 be different for different TCI states. This configuration possibility will never be utilized, so it must be possible to avoid it.  P1.2: Support  P1.3A: OK without “a single RRC pool of TCI states is used”. TCI stats pool is a different issue, and should be treated as such  P1.3B: We have concerns, if this would mandate the NW to configure CSI-RS with repetition ON  P1.4: OK with the original formulation. Like MTek, we do not see what DL RS or channel that can be a *target* of a R15/16 spatial relation  P1.5: OK to discuss. Just as in R16, we think that it is relevant that the UE performs measurement on any type of CSI-RS using the QCL properties of PDCCH/PDSCH. With such a rule, we also reduce the need for aperiodic triggering states, which is bottleneck in practical implementation.  P1.6: OK to discuss. We prefer no mix of R15/16 and R17 TCI states, i.e., Alt2.  Conclusion 1.7: OK |
| CMCC | Proposal 1.1~1.2: Support  Proposal 1.3: We prefer Alt1, but open to discuss further.  Proposal 1.4~1.6: Support.  Conclusion 1.7: CSI-RS for CSI is already supported as the source RS to determine the QCL of DM-RS of PDCCH and DM-RS of PDSCH in Rel-15/Rel-16. We should respect the previous agreement, which implies CSI-RS for CSI is also agreed. |
| Nokia/NSB | Proposal 1.1: Support in principle  Proposal 1.2: Support in principle  Proposal 1.3A vs 1.3B: support 3A  Proposal 1.4: OK.  Proposal 1.5: OK.  Proposal 1.6: OK.  Conclusion 1.7: not needed! |
| CATT | Proposal 1.3A vs. 1.3B: support 3A. |
| Qualcomm | Proposal 1.1: OK  Proposal 1.2: OK  Proposal 1.3A vs 1.3B: Support 1.3B whose meaning is at least clear. We don’t understand 1.3A, which says in 1st sub-bullet that a CC-specific RS is determined to provide QCL-D, and the CC-specific source RSs for the set of CCs are further associated with a same QCL-D RS. What does this mean? Why needs to further associate with same QCL-D? Also, in the note, it says a single RS is used to provide QCL-D across the CCs. But this conflicts with the 1st sub-bullet, which says that QCL-D is CC-specific. So we could not understand 1.3A and tried to clarify the meaning in our previous response.  Proposal 1.4: The new modification seems incorrect. DL RS/channel cannot be a target of R15/16 spatial relation. Suggest to list spatial relation as a separate bullet. Also, suggest to change “DL TCI” to “DL and joint TCI” in 1st bullet.  Proposal 1.5: Fine to discuss.  Proposal 1.6: This needs to be discussed after 1.4. Because we don’t think there should be any RS/channel that cannot share the R17 TCI. |

### Issue 2 (L1/L2-centric inter-cell mobility)

Table 3 Summary: issue 2

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1 | Support CSI-RS associated with/configured for non-serving cell(s) as a measurement RS  Note: Supporting this implies the support of Rel-15 CSI-RSRP as beam metric/reporting | CSI-RS for mobility/RRM associated with NSC:   * **Yes**: Lenovo/MoM, Huawei, HiSi, Sony, LG, ZTE, CATT * **No**: Nokia/NSB, Samsung, OPPO, MTK, Xiaomi, NTT Docomo   CSI-RS for BM configured for NSC:   * **Yes**: Nokia/NSB, Ericsson, AT&T, ZTE, APT/FGI * **No**: Samsung, OPPO, MTK, Xiaomi, NTT Docomo   CSI-RS for tracking (TRS) configured for NSC:   * **Yes**: -- * **No**: Samsung, OPPO, MTK, NTT Docomo |
| 2.2 | Maximum value of K (beams associated at least with non-serving cell(s) reported in a single CSI reporting instance), i.e. KMAX  Note: UE capability of supporting < KMAX is neither ruled out nor within the scope of 2.2 | **4**: vivo, Spreadtrum, MTK (if cell = 1),OPPO  **8**: Nokia/NSB, Ericsson, AT&T, CATT (at least), MTK (if cells > 1), APT/FGI  **16**: Huawei, HiSi, Samsung, ZTE , NTT Docomo |
| 2.3 | How to set the value of K≤ KMAX  Alt1: RRC configured (based on UE capability)  Alt2: Dynamically selected by UE (indicated in CSI reporting, two-part UCI) | **Alt1**: OPPO, MTK, CATT, Intel, ZTE, Xiaomi, NTT Docomo, APT/FGI  **Alt2**: Samsung |
| 2.4 | The maximum value of NMAX (number of non-serving cell(s) RRC configured for measurement/reporting)  Note: UE capability of supporting <Nmax is neither ruled out nor within the scope of 2.4 | **1**: Spreadtrum, OPPO  **>1 (specify)**: Ericsson (FFS the maximum value), CATT, Samsung (4), Xiaomi (3) , ZTE, NTT Docomo |
| 2.5 | Whether to support the following reporting behavior | Periodic**:**   * **Yes**: Nokia/NSB, MTK, Samsung (with restriction), Spreadtrum, ZTE, NTT Docomo, CATT, Ericsson * **No**:   Semi-persistent**:**   * **Yes**: Nokia/NSB, MTK, Samsung, ZTE, Spreadtrum, NTT Docomo, CATT, Ericsson * **No**:   Aperiodic**:**   * **Yes**: Nokia/NSB, MTK, Samsung, ZTE, Spreadtrum, NTT Docomo, CATT, Ericsson * **No**:   Event-driven**:**   * **Yes (specify event)**: Nokia/NSB, Xiaomi (L1 event), ZTE (event triggered by L3 mobility measurement), Apple (L1-RSRP of NSC is beyond L1-RSRP of SC plus an offset), AT&T, Sony (L1 metric of NSC is beyond L1 metric of SC plus an offset), Qualcomm, Samsung, LG, CATT * **No**: MTK, Ericsson |
| 2.6 | Supported DL QCL Type-D and/or UL TX spatial reference source RS type(s) for L1/L2-centric inter-cell mobility by extending Rel-17 unified TCI framework to inter-cell indication | DL QCL Type-D:   * *SSB associated with NSC as direct QCL source:*    + **Yes**: Nokia/NSB, Samsung, MTK, NTT Docomo, ZTE, Xiaomi, CATT   + **No**: Ericsson * *SSB associated with NSC as indirect QCL source (therefore any CSI-RS resource using NSC SSB can be used as a source RS):*    + **Yes**: CMCC, Nokia/NSB, Samsung, Sony, Ericsson, MTK, NTT Docomo, ZTE, LG, Xiaomi, CATT   + **No**: * *CSI-RS for RRM:*    + **Yes:** Sony, LG   + **No:** Samsung, MTK, Ericsson   UL TX spatial reference:   * *SSB associated with NSC as direct QCL source:*    + **Yes**: CMCC, Samsung, Sony, Ericsson, MTK, ZTE, Xiaomi, NTT Docomo, CATT   + **No**: * *SSB associated with NSC as indirect QCL source (therefore any CSI-RS resource using NSC SSB can be used as a source RS):*    + **Yes**: CMCC, Samsung, Sony, Ericsson, MTK, ZTE, LG, Xiaomi, NTT Docomo, CATT   + **No**: * *CSI-RS for RRM:*    + **Yes**: Sony, LG   + **No**: Samsung, MTK, Ericsson |
| 2.7 | Whether to support the following Rel-17 unified TCI types for L1/L2-centric inter-cell mobility | Joint TCI:   * **Yes**: Samsung, vivo, Nokia/NSB, MTK, ZTE, LG, Xiaomi, NTT Docomo, CATT, Ericsson * **No**:   Separate DL/UL TCI (including DL-only, UL-only, and [DL+UL]):   * **Yes**: vivo, Nokia/NSB, MTK, NTT Docomo, CATT * **No**: Samsung (FFS), ZTE (FFS is needed), Ericsson (FFS) |
|  |  |  |

The following observation can be made:

* (2.6, 2.7) For beam indication, at the minimum, indirect QCL with SSB from NSC seems agreeable as a method for spatial reference. In addition, joint TCI can be agreed.
* (2.1) This issue has been discussed for several meetings and there is no consensus (the situation hasn’t changed)
* (2.2) Kmax=8 represents the majority view
* (2.5) No objection to support P/SP/AP, and the majority supports L1-based event-driven reporting

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

**Proposal 2.1**: On Rel.17 beam indication enhancements for L1/L2-centric inter-cell mobility, support the following:

* At least for UE reception and transmission assocaited with UE-dedicated CORESETs, Rel-17 MAC-CE-based and DCI-based beam indication (using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation) for joint TCI state
  + FFS (to be decided in RAN1#106-e): Beam indication support for separate DL/UL TCI in case of L1/L2-centric inter-cell mobility
* The DL QCL and UL spatial relation rules already agreed for intra-cell scenario, also allowing the use of SSB associated with a physical cell ID different from that of the serving cell as a direct/indirect QCL reference, except for a direct QCL reference for UE-dedicated PDCCH/PDSCH
  + Note: When RS X is an indirect QCL reference of a target channel, RS X serves as a QCL source RS of the source RS configured for the target channel.
  + FFS (to be decided in RAN1#106-e): Whether SSB associated with a physical cell ID different from that of the serving cell can also be used as a direct QCL reference (source RS) for UE-dedicated PDCCH/PDSCH

**Conclusion 2.2**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP, there is no consensus on supporting CSI-RS for mobility/RRM associated with non-serving cell as measurement RS in RAN1#105-e

**Proposal 2.3**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,

* Support at least K=4, where K is defined as the number of beams associated at least with non-serving cell(s) reported in a single CSI reporting instance
  + The maximum value of supported K is a UE capability
  + FFS: The support of K=8 and 16
    - For K>4, the maximum number of beams associated with one cell is 4
* Support NW-controlled periodic, semi-persistent, and aperiodic reporting
  + FFS: Restriction for periodic reporting, e.g. smaller value(s) of K, number of non-serving cells
* Support L1-based event-driven reporting
  + FFS: Definition of L1-based event, if needed

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 | P2.1: Support  P2.2: Support  P2.3: Support in principle. Regarding K=8, we prefer to support it only when a reporting is associated with more than cells (NSCs and/or SC). Otherwise, we don't see the need to support more than four if a reporting is associated with only one NSC.  [Mod: Agree, added] |
| Intel | Proposal 2.1: Not ok with the first sub-bullet. MAC-CE activation and TCI state mapping to codepoints for intra-cell is not finalized. For example, if dynamic indication is agreed where both joint and separate DL/UL TCI can be mapped to codepoints, only joint TCI state update is an added constraint and it is not clear why we should agree to this at this point. We can put the entire MAC-CE based codepoint activation part in the FFS.   * Rel-17 DCI-based beam indication (using DCI formats 1\_1/1\_2 with and without DL assignment~~, including the associated MAC-CE-based TCI state activation) with the TCI field used to update joint TCI state~~   + FFS (to be decided in RAN1#106-e): MAC-CE-based TCI state activation and the use of the TCI field to update joint or separate DL/UL TCI states   [Mod: The intention of this bullet is to agree on supporting joint TCI only, for now. While separate TCI is FFS. It has nothing to do with switching between joint and separate. Reworded accordingly] |
| Qualcomm | For Proposal 2.1   * Suggest to add “at least”   + Rel-17 DCI-based beam indication (using DCI formats 1\_1/1\_2 with and without DL assignment, including the associated MAC-CE-based TCI state activation) with the TCI field used to update at least joint TCI state * Suggest to add “for PDCCH/PDSCH”, because SSB should be allowed to be as direct QCL source at least for CSI-RS. Otherwise, it is unclear how this indirect QCL for any channel/RS works.   + The DL QCL and UL spatial relation rules already agreed for intra-cell scenario, also allowing the use of SSB associated with a physical cell ID different from that of the serving cell as an indirect/direct QCL source, except for a direct QCL source for PDCCH/PDSCH     - FFS (to be decided in RAN1#106-e): Whether SSB associated with a physical cell ID different from that of the serving cell can also be used as a direct QCL source for PDCCH/PDSCH (source RS)   [Mod: Please check latest version. Done. ]  For Conclusion 2.2: Support  For Proposal 2.3: Support |
| Apple | Proposal 2.1: one minor suggestion as follows, since we also support MAC CE based beam indication in R17  **Proposal 2.1**: On Rel.17 beam indication enhancements for L1/L2-centric inter-cell mobility, support the following:   * Rel-17 MAC CE and DCI-based beam indication (using DCI formats 1\_1/1\_2 with and without DL assignment, including the associated MAC-CE-based TCI state activation) with the TCI field used to update joint TCI state   + FFS (to be decided in RAN1#106-e): The use of the TCI field to update separate DL/UL TCI states * The DL QCL and UL spatial relation rules already agreed for intra-cell scenario, also allowing the use of SSB associated with a physical cell ID different from that of the serving cell as an indirect QCL source   + FFS (to be decided in RAN1#106-e): Whether SSB associated with a physical cell ID different from that of the serving cell can also be used as a direct QCL source (source RS)   Proposal 2.2: Support  Proposal 2.3: We have concerns for aperiodic report. UE has to measure corresponding SSB to get ready for potential beam report triggering, but UE does not know when this report would be triggered. This waste UE power quite a lot. So, we suggest the following change.  **Proposal 2.3**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * Support at least K=4 and 8, where K is defined as the number of beams associated at least with non-serving cell(s) reported in a single CSI reporting instance   + The maximum value of supported K is a UE capability   + FFS: The support of K=16 * Support NW-controlled periodic, and semi-persistent reporting   + FFS: Restriction for periodic reporting, e.g. smaller value(s) of K, number of non-serving cells * Support L1-based event-driven reporting   + FFS: Definition of L1-based event   [Mod: Since majority would like to support aperiodic as well (even as a primary mode), I will keep the proposal as is, and we can further discuss, e.g. perhaps the concern can be addressed with activation/deactivation] |
| Samsung | Proposal 2.1: In general, the direction of the proposal is fine. We have not, based on my knowledge, define indirect SSB. I think we should define if we include in proposal to be clear. Alternatively we can avoid this wording as follows:   * The DL QCL and UL spatial relation rules already agreed for intra-cell scenario, also allowing the use of ~~SSB~~ at least a reference signal associated with an antenna port of a physical cell ID different from that of the serving cell as ~~an indirect~~ QCL source   + FFS (to be decided in RAN1#106-e): Whether SSB associated with a physical cell ID different from that of the serving cell can also be used as a direct QCL source (source RS)   At least is added to cover the FFS which would be an additional RS  [Mod: Since the use of SSB as an indirect QCL is the main point of this bullet, removing SSB and replacing with antenna port as proposed could cause further confusion and ambiguity.]  Conclusion 2.2: Support  Proposal 2.3: Support direction of proposal. We think that the last bullet should be FFS in its entirety as we have not define what the event is:   * FFS: Support L1-based event-driven reporting   + ~~FFS:~~ Definition of L1-based event   [Mod: Ideally the group can agree on everything at once, but there is a strong majority for supporting L1-based event driven (including Samsung). Leaving the whole thing FFS doesn’t provide much progress from the last meeting.] |
| OPPO | 2.1：The main purpose of this proposal is to reuse the agreed DCI-based beam indication for inter-cell mobility. Then we only need to say this and the details for joint TCI or separate TCI can be removed for current moment. And as in Conclusion 1.7, there is no consensus to support SSB as direct QCL, we do not see why we need the second FFS.  **Proposal 2.1**: On Rel.17 beam indication enhancements for L1/L2-centric inter-cell mobility, support the following:   * Rel-17 DCI-based beam indication (using DCI formats 1\_1/1\_2 with and without DL assignment, including the associated MAC-CE-based TCI state activation) with the TCI field is used ~~to update joint TCI state~~   + ~~FFS (to be decided in RAN1#106-e): The use of the TCI field to update separate DL/UL TCI states~~ * The DL QCL and UL spatial relation rules already agreed for intra-cell scenario, also allowing the use of SSB associated with a physical cell ID different from that of the serving cell as an indirect QCL source   + ~~FFS (to be decided in RAN1#106-e): Whether SSB associated with a physical cell ID different from that of the serving cell can also be used as a direct QCL source (source RS)~~   [Mod: Please check latest version. The purpose is to agree only on joint TCI and have separate FFS]  Conclusion 2.2: suggest to remove “in RAN1#105-e”. Let us make a conclusion and stop discussing it.  [Mod: From FL perspective, this is the best I can do. The chairman will have to change this per your suggestion (similar to last meeting on source RS issue). We will leave it to the chairman]  2.3: we have concern on K =8. There is no justification to support so many. Suggest to only support K = 4.  [Mod: Now in brackets] |
| ZTE | Proposal 2.1: Support. Also we are fine with Apple’s update for MAC-CE based beam indication  Proposal 2.2: Definitely not our preference, but we can live with this proposal for progress.  [Mod: Thanks for your understanding]  Proposal 2.3: We suggest to support K=16 in this proposal from spec perspective, and UE vendor can report capability signaling of the maximum number of K to be supported. Meanwhile, we can NOT live with K=4 only as OPPO suggested, and it significantly weakens the benefits of NSC-measurement (also relevant to spec forward compatibility) from gNB vendor perspective.  [Mod: I understand, but it seems even K=8 is being contested] |
| LG | For Proposal 2.1: Support in principle. However, the DCI format 0\_1/0\_2 for Rel-17 beam indication also can be considered, which is up to the result of Issue#3.  For Proposal 2.3, it seems too early to support K>4 until details of reporting method is fixed. If we simply reuse existing beam reporting, K=4 may be sufficient. |
| Xiaomi | Proposal 2.1, share same view as apple to add “MAC CE”  Conclusion 2.2, support  Proposal 2.3, as for K=8, we think it is better to discuss it after the maximum number of non-serving cell is decided. |
| NTT Docomo | Proposal 2.1: Support. We are fine with adding “MAC CE” by Apple, because DCI indication of unified TCI is agreed as optional feature in RAN1#104bis-e. If possible, we’d like to clarify the "indirect QCL source" to avoid ambiguity.  [Mod: Done]  Proposal 2.2 - 2.3: Support. |
| CATT | Proposal 2.1: Support  Conclusion 2.2: Support  Proposal 2.3: On the second subbullet, we think the “FFS” issue can be achieved by implementation, but we are fine to leave it there.  [Mod: Agree, added ‘if needed’] |
| Mod V16 | Revised proposals to address the above inputs  **Please check the latest version of FL proposals** |
| vivo | It seems that we still do not have RAN2 LS feedback on how UE interprets such beam update, i.e., whether there is serving cell change or not. For the current formulation, we would like to focus on UE dedicated reception part.  **Proposal 2.1**: On Rel.17 beam indication enhancements for L1/L2-centric inter-cell mobility, support the following:   * For UE reception and transmission associated with UE dedicatedly configured CORESETs, Rel-17 MAC-CE-based and DCI-based beam indication (using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation) for joint TCI state   + FFS (to be decided in RAN1#106-e): Beam indication support for separate DL/UL TCI in case of L1/L2-centric inter-cell mobility * The DL QCL and UL spatial relation rules already agreed for intra-cell scenario, also allowing the use of SSB associated with a physical cell ID different from that of the serving cell as a direct/indirect QCL reference, except for a direct QCL reference for UE-dedicated PDCCH/PDSCH   + Note: When RS X is an indirect QCL reference of a target channel, RS X serves as a QCL source RS of the source RS configured for the target channel.   + FFS (to be decided in RAN1#106-e): Whether SSB associated with a physical cell ID different from that of the serving cell can also be used as a direct QCL reference (source RS) for UE-dedicated PDCCH/PDSCH   [Mod: Sure.]  Regarding conclusion 2.2, we would like to understand what it means by “CSI-RS for BM configured for non-serving cell” and “CSI-RS for tracking configured for non-serving cell”. The conclusion should be captured in a way that the CSI-RS for BM and CS-RS for tracking associated with an SSB from non-serving cell should not be precluded.  **Conclusion 2.2**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP, there is no consensus on supporting the following measurement RS types in RAN1#105-e:   * CSI-RS for mobility/RRM associated with non-serving cell * CSI-RS for BM configured for non-serving cell * CSI-RS for tracking configured for non-serving cell   [Mod: Good point. I think we can remove the 2nd and 3rd bullets for now]  Regarding 2.3, we would also like to put aperiodic reporting in brackets at this stage before we have clear understanding on how the non-serving cell RS are measured.  **Proposal 2.3**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * Support at least K=4, where K is defined as the number of beams associated at least with non-serving cell(s) reported in a single CSI reporting instance   + The maximum value of supported K is a UE capability   + FFS: The support of K=8 and 16     - For K>4, the maximum number of beams associated with one cell is 4 * Support NW-controlled periodic, semi-persistent[, and aperiodic reporting]   + FFS: Restriction for periodic reporting, e.g. smaller value(s) of K, number of non-serving cells * Support L1-based event-driven reporting   FFS: Definition of L1-based event, if needed  [Mod: Perhaps the technical concern on NSC measurement should be articulated first so some discussion can happen. Is it related to the activation issue? Note that aperiodic reporting is typically the main operational mode in CSI/beam reporting.] |
| Mod V20 | Revised proposals to address the above inputs  **Please check the latest version of FL proposals** |
| Lenovo/Motorola Mobility | Proposal 2.1: Support.  Conclusion 2.2: We still think it is helpful to use support CSI-RS for mobility for L1/2 inter-cell mobility, but we can go with the majority view for the sake of progress.  Proposal 2.3: Support in principle. Regarding the third bullet “L1-based event-driven reporting”, we think it is necessary to define L1-based event first. |
| MediaTek | P2.1: Regarding the added sentence “At least for UE reception and transmission associated with UE-dedicated CORESETs”, we think UE-dedicated data reception should be supported as well.  We would like to add one FFS to study whether UE can support the activated TCI states are associated with RSs configured for more than one cells simultaneously. It could be difficult for UE to be dynamically switched between different cells based on DCI indication if the timing difference cannot be guaranteed.   * At least for UE reception and transmission associated with UE-dedicated CORESETs and PDSCH receptions, Rel-17 MAC-CE-based and DCI-based beam indication (using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation) for joint DL/UL TCI ~~state~~   + FFS (to be decided in RAN1#106-e): Beam indication support for separate DL/UL TCI in case of L1/L2-centric inter-cell mobility   + FFS: Whether to support activation of TCI states for more than one cells simultaneously   P2.2: Okay  P2.3: We would like to clarify how K is provided is this proposal. In our view, it should be configured by NW based on the UE capability.   * Support at least K=4, where K is defined as the number of beams associated at least with non-serving cell(s) reported in a single CSI reporting instance   + The maximum value of supported K is a UE capability   + K is configured by NW based on the UE capability |
| Ericsson | P2.1: Support.  P2.2: OK  P2.3: Why is this one proposal? We are not OK to agree to event-driven reporting. At best, this is essentially BFR-light, which will require heavy involvement from RAN2, since RAN1 specifications are stateless. Both the triggering condition, and the reporting procedure would have to be in RAN2 specifications. The benefit is also unclear. |
| CMCC | Proposal 2.1~2.2: Support.  Proposal 2.3: Suggest to discuss the supported number of non-serving cells first. |
| Nokia/NSB | Proposal 2.1: Similar views as Intel and OPPO, we are not OK with the mention of joint TCI in the first sub-bullet as long as the framework is being discussed in a different discussion item. In fact we also prefer to discuss such issues more in the mTRP agenda, we have simulation results in this meeting showing that there are unclear (if no benefits) of the L1/2 mobility as such, w.r.t L3 operation. The only purpose we see for the continuation of this discussion is if the operation framework is under mTRP.  Conclusion 2.2: OK.  Proposal 2.3: we are not OK with the last bullet, a similar proposal was in the last meeting and as long as the “ o FFS: Definition of L1-based event, if needed” is not clarified, for us this proposal is a hard to take! |
| Qualcomm | Proposal 2.1: OK  Conclusion 2.2: OK. Should we also list CSI-RS for BM and TRS as FFS to conclude them in this meeting?  Proposal 2.3: OK |

### Issue 3 (beam indication signaling medium)

Table 5 Summary: issue 3

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| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 3.1 | Whether both DL TCI and UL TCI states can be signaled in one instance of beam indication DCI formats 1\_1/1\_2 (with and without DL assignment) | **Yes (one TCI field codepoint represents both DL and UL TCI states)**: Nokia/NSB, Ericsson, Samsung, Xiaomi, OPPO, Fujitsu, Intel, NTT Docomo, CATT  **No**: |
| 3.2 | Beam application time (BAT):   * Alt1: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the DCI with the joint or separate DL/UL beam indication * Alt2A: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the acknowledgment of the joint or separate DL/UL beam indication * Alt 2B: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the acknowledgment of the joint or separate DL/UL beam indication, except that the (new) TCI state update can be applied to the PDSCH, if it exists, (scheduled by the beam indication DCI) and corresponding ACK transmission (provided that the time offset between the DCI and the scheduled PDSCH exceed the threshold, analogous to Rel.15/16) * Alt2C: Support both Alt1 and Alt2A, and introduce a UE capability that indicates the support of Alt1 or Alt2A * Alt3: the first slot that is at least X1 ms or Y1 symbols after the [first/last] symbol of the DCI with beam indication and X2 ms or Y2 symbols after the [first/last] symbol of the acknowledgment of the beam indication | **Alt1**: vivo, Ericsson, Xiaomi, Convida  **Alt2A**: Lenovo/MoM, CMCC, Fujitsu, Samsung (2nd preference), IDC, Spreadtrum, ZTE, CATT, Huawei, HiSi, Apple, Sony, Qualcomm, NEC, NTT Docomo (2nd preference), APT/FGI, MTK, Intel, OPPO (2nd preference: Alt2B+ meet the UE capability), ZTE, Ericsson (2nd preference)  **Alt2B**: Nokia/NSB, Samsung (1st preference), Xiaomi, NTT Docomo (1st preference), LG  **Alt2C:**  **Alt3**: OPPO |
| 3.3 | For a UE configured with (supporting/capable of) both joint TCI and separate DL/UL TCI (including DL-only TCI, UL-only TCI, [or DL+UL TCI]), how to signal the switching between joint TCI and separate DL/UL TCI:   * AltA. Either joint TCI, DL-only TCI, UL-only TCI, [or DL+UL TCI] can be dynamically indicated via beam indication DCI (i.e. the 8 available TCI codepoints are partitioned for all the TCI “types”) * AltB. Either joint DL/UL TCI or separate DL/UL TCI can be activated via MAC CE signaling (included in the TCI state activation)   + When separate DL/UL TCI is activated, either DL-only TCI, UL-only TCI, [or DL+UL TCI] can be indicated via beam indication DCI   Note: The UE capability/optionality/FG issue is beyond the scope of 3.2 | **AltA**: Lenovo/MoM, Nokia/NSB, ZTE, OPPO (only for the UE with UE capability supporting both joint and separate TCI state), Sony, Convida, APT/FGI, Intel (TCI state usage indication via MAC-CE and dynamic switching using DCI), CATT  **AltB**: Spreadtrum, CATT, Ericsson, Huawei, HiSi, Samsung, Xiaomi, Apple, Qualcomm, MTK, NTT Docomo, LG |
| 3.4 | Additional support for DCI ACK/NAK for DCI formats 1\_1/1\_2 with DL assignment when used for beam indication | **Yes:** Lenovo/MoM (dedicated ACK/NACK bit in codebook), Xiaomi (separate HARQ-ACK bit), Samsung, CATT (only ACK), OPPO (only ACK), Apple, NEC (only ACK)  **No:** ZTE (FFS is needed), Ericsson |
| 3.5 | Support for additional DCI formats for Rel-17 unified TCI framework beam indication (TCI state update) beyond the agreed DCI formats 1\_1/1\_2 with + without DL assignment | **No additional DCI format is supported for beam indication:** Convida, OPPO, NTT Docomo, CATT, Ericsson  **DCI formats 0\_1/0\_2 with UL grant (for UL-only TCI of separate DL/UL TCI)**: IDC, Sony, NEC, MTK, LG, Intel, ZTE, Xiaomi |
| 3.6 | When more than one TCI codepoints are activated by MAC CE, the activated TCI state(s) for the lowest codepoint is/are applied. | **Yes:** Huawei, HiSi, Ericsson  **No:** Intel, OPPO, ZTE |
| 3.7 | When UE is configured with two HARQ priorities, the HARQ ACK/NACK feedback for beam indication DCI is always mapped to high priority codebook with PUCCH resource associated to priority index 1 | **Yes:** Intel  **No:** |

The following observation can be made:

* (3.1) Majority support for signaling both DL and UL TCI in one beam indication instance for separate TCI
* (3.2) Alt2A seems to be the alternative acceptable to (almost) all companies
* (3.3) AltB (MAC-CE-activation based) represents the majority viee and the middle ground between RRC-based (too slow) and codepoint-based (over-partitioning the max 8 available codepoints into joint and separate TCIs – 4 “types” of TCI) switching between joint and separate TCI. It also accommodates (partially) the view of those preferring fully dynamic switching (since the switching among DL, UL, and DL+UL is done via TCI field codepoints)

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

**Proposal 3.1**: On Rel-17 unified TCI, for separate DL/UL TCI, one instance of beam indication using DCI formats 1\_1/1\_2 (with and without DL assignment) can be used as follows:

* One TCI field codepoint represents a pair of DL TCI state and UL TCI state
* One TCI field codepoint represents only a DL TCI state
* One TCI field codepoint represents only an UL TCI state

**Proposal 3.2**: On Rel-17 DCI-based beam indication, regarding application time of the beam indication, the first slot that is at least X ms or Y symbols after the last symbol of the acknowledgment of the joint or separate DL/UL beam indication.

* The gap between the last symbol of the beam indication DCI and that first slot shall satisfy the UE capability
* FFS: whether additional offset for the application time of cross carrier beam indication is needed

**Proposal 3.3**: On Rel-17 unified TCI, for a UE configured with both joint TCI and separate DL/UL TCI (including DL-only TCI, UL-only TCI, or DL+UL TCI), either only joint DL/UL TCI states or only separate DL/UL TCI states can be activated via MAC-CE-based TCI state activation

* When joint TCI states are activated, only joint TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication
  + Here, only TCI states corresponding to the joint TCI are activated.
* When separate DL/UL TCI states are activated, either DL-only TCI state, UL-only TCI state, or DL+UL TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication
  + Here, only TCI states corresponding to the separate DL/UL TCI are activated
* Detailed MAC-CE-based design on how to activate either only joint DL/UL TCI states or only separate DL/UL TCI states is up to RAN2

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 | P3.1: Support  P3.2: Support  P3.3: Support. Regarding how to activate joint TCI or separate TCI via MAC-CE-based TCI state activation can be left to RAN2 design.   * *How to activate either only joint DL/UL TCI states or only separate DL/UL TCI states is up to RAN2*   [Mod: Agree, done] |
| Nokia/NSB | Proposal 3.1: Support  Proposal 3.2: Support  Proposal 3.3: We prefer no ‘mode like’ separation between indication of joint/separated TCI, since it can be up to gNB which TCI to be associated to each of TCI index. But as our 2nd preference, we can be open for MAC CE based switching. We do not support any slower changes, e.g., RRC.  [Mod: Thanks for your understanding] |
| Intel | Proposal 3.1: Support  Proposal 3.2: Support  Proposal 3.3: Do not support this proposal. We don’t see the need to limit the configurable codepoints to one type of TCI states. As we outlined in our paper, MAC-CE configuring the TCI codepoints can also configure the usage i.e., what type of TCI state the codepoint maps to. In this case, the DCI indication can choose any of the 8 codepoints and they can map to either joint or separate TCI states. Requiring MAC-CE to reconfigure codepoints if gNB needs to indicate separate TCI states is not desirable.  [Mod: The proponents of MAC CE based switching are concerned that using code-point-based switching between joint and separate will cause much more frequent use of MAC CE activation especially at high-speed. In addition, code-point-based switching has been used within 2-3 types of TCI in separate TCI. This is already a middle ground.]  We also added Issue 3.7 to the Table 5. In our understanding, the ACK/NACK for beam indication is a very important UCI which is needed to ensure UE and gNB are aligned on which beam is used. In this case, this ACK/NACK feedback should not be dropped in favor of other UCI i.e., prioritization is needed. For the case when a UE is configured with two HARQ codebook priority indices, the beam indication ACK/NACK should always be mapped to the high priority HARQ/ACK codebook. |
| Qualcomm | For Proposal 3.1: Can more details be provided? How?  [Mod: please check latest version. One codepoint mapped to both DL and UL, c.f Fraunhofer’s comment]  For Proposal 3.2: Support  For Propoal 3.3: Suggest the following clarification if that is the intention  **Proposal 3.3**: On Rel-17 unified TCI, for a UE configured with both joint TCI and separate DL/UL TCI (including DL-only TCI, UL-only TCI, or a pair of DL+UL TCIs if supported), either only joint DL/UL TCI states or only separate DL/UL TCI states can be activated via MAC-CE-based TCI state activation   * When joint TCI states are activated, only joint TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication * When separate DL/UL TCI states are activated, either a single DL-only TCI state, a single UL-only TCI state, or a pair DL+UL TCI states if supported can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication   [Mod: Please check latest wording based on OPPO’s input – should address your input] |
| Apple | Proposal 3.1: Support  Proposal 3.2: Support  Proposal 3.3: For separate DL/UL, we suggest one code-point is always mapped to a pair of DL+UL TCI. So we suggest the following change:  **Proposal 3.3**: On Rel-17 unified TCI, for a UE configured with both joint TCI and separate DL/UL TCI (including DL-only TCI, UL-only TCI, or DL+UL TCI), either only joint DL/UL TCI states or only separate DL/UL TCI states can be activated via MAC-CE-based TCI state activation   * When joint TCI states are activated, only joint TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication * When separate DL/UL TCI states are activated, DL+UL TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication   [Mod: Since we already agreed to signal DL-only and UL-only for separate (below), we cannot remove these options unless all companies agree ☹   * *Use the existing TCI field (always present) to signal the following: 1) Joint DL/UL TCI state, 2) DL-only TCI state (for separate DL/UL TCI), 3) UL-only TCI state (for separate DL/UL TCI)*    + *FFS: Whether both DL TCI and UL TCI states can be signaled in one instance of beam indication DCI* ] |
| Samsung | Proposal 3.1: Support  Proposal 3.2: Support  Proposal 3.3: Support |
| OPPO | Proposal 3.1: The wording is confusing a little bit. Does the proposal intent to say that a single DCI can indicate one DL TCI state and one UL TCI state? Suggest to change as follows:  **Proposal 3.1**: On Rel-17 unified TCI, for separate DL/UL TCI, ~~both DL-only TCI and UL-only TCI states can be updated in~~ one instance of beam indication using DCI formats 1\_1/1\_2 (with and without DL assignment) can indicate one DL TCI state and one UL TCI state.    Proposal 3.2: We prefer to add a note that the gap between the beam indication DCI and that first slot shall satisfy the UE capability.  **Proposal 3.2**: On Rel-17 DCI-based beam indication, regarding application time of the beam indication, the first slot that is at least X ms or Y symbols after the last symbol of the acknowledgment of the joint or separate DL/UL beam indication.   * The gap between the last symbol of the beam indication DCI and that first slot shall satisfy the UE capability   Proposal 3.3: support in principle. But prefer to clarify that in one single MAC CE, all the activated TCI states shall be the same type: all are joint TCI states or all are separate TCI states.  **Proposal 3.3**: On Rel-17 unified TCI, for a UE configured with both joint TCI and separate DL/UL TCI (including DL-only TCI, UL-only TCI, or DL+UL TCI), either only joint DL/UL TCI states or only separate DL/UL TCI states can be activated via MAC-CE-based TCI state activation   * When joint TCI states are activated, only joint TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication, here all the activated TCI states are joint TCI states. * When separate DL/UL TCI states are activated, either DL-only TCI state, UL-only TCI state, or DL+UL TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication, here all the activated TCI states are separate DL/UL TCI states.   [Mod: Thanks for the good wording suggestions. Done.] |
| ZTE | Proposal 3.1: Support  Proposal 3.2: Support. Xms is slightly preferred considering that different SCS may be configured for different CCs in CA case.    Proposal 3.3: Support. We think that for separate beam indication mode (as a super mode compared with joint TCI indication), we also need to support a beam state that can be applied to both DL and UL as a joint TCI state by default. |
| LG | Proposal 3.1: Suggest to discuss whether to support DCI format 0\_1/0\_2 for UL TCI update before discussing this proposal. If it is supported, it seems not needed to use DL DCI format (i.e. 1\_1/1\_2) for UL TCI update in case of separate DL/UL TCI.  [Mod: I don’t see any correlation with this, however]  Proposal 3.2: We have strong concern on this proposal. The main difference between Alt2A and Alt2B is whether to apply the indicated TCI in DCI to the scheduled PDSCH. Could someone explain why the indicated TCI by DCI should NOT be applied to the scheduled PDSCH, which is an existing functionality? Alt2A will lead to worse performance than Rel-15/16, i.e. PDSCH beam application timing is delayed after sending HARQ-ACK for the scheduled PDSCH, which is very strange design.  [Mod: Alt2B is largely based on Alt2A except with enhanced/different definition for PDSCH. Your argument is valid. But many companies have expressed strong concern on having different BAT definition only for PDSCH, and only for 1\_1/1\_2 with DL assignment.]  Proposal 3.3: Support in principle. Need to remove ‘DL+UL TCI state’ by DCI 1\_1/1\_2 for now due to the reason commented on 3.1  [Mod: we can put this in brackets for now until 3.1 is agreed.] |
| Xiaomi | Proposal 3.1, support  Proposal 3.2, For the DCI format with DL assignment, we slightly prefer Alt 2B.  Proposal 3.3, support. |
| NTT Docomo | Support proposal 3.1/3.2/3.3. |
| Fraunhofer IIS/HHI | In proposal 3.1, it is better to clarify if one instance means one DCI with 2 fields with one indicating a DL and a second indicating a UL TCI state, or one codepoint of a DCI field indicating both UL and DL TCI states. And, the part “with or without DL assignment” can be included without brackets in the main bullet or as a note in a sub-bullet.  [Mod: It is the second. Pleae check the latest. Done.]  Support 3.2 and 3.3. |
| CATT | Proposal 3.1: Support  Proposal 3.2: Support  Proposal 3.3: we are OK with the proposal. |
| Mod V16 | Revised proposals to address the above inputs  **Please check the latest version of FL proposals** |
| Vivo | Support proposal 3.1  Regarding proposal 3.2, we would like to understand how this is applied for cross carrier beam indication case. In Rel-16 discussion, additional time-offset is applied for the beam indication timing when the scheduling cc numerology is different from scheduled cc numerology.  **Proposal 3.2**: On Rel-17 DCI-based beam indication, regarding application time of the beam indication, the first slot that is at least X ms or Y symbols after the last symbol of the acknowledgment of the joint or separate DL/UL beam indication.   * The gap between the last symbol of the beam indication DCI and that first slot shall satisfy the UE capability * FFS additional offset for the application time of cross carrier beam indication.   [Mod: Done]  Support proposal 3.3. |
| APT/FGI | Proposal 3.1: OK with the main bullet.  Proposal 3.2: support |
| Samsung2 | We are fine with proposal 3.1, it would be good to add a note that a “codepoint represents a pair of DL-only and UL-only TCI states” is in addition to DL only TCI codepoint and UL only one TCI codepoint.  [Mod: Done]  For proposal 3.3, as we have not defined “DL/UL TCI state” we should avoid this term. Suggest the following update:  **Proposal 3.3**: On Rel-17 unified TCI, for a UE configured with both joint TCI and separate DL/UL TCI (including DL-only TCI, UL-only TCI, or DL+UL TCI), either only joint DL/UL TCI states or only separate DL/UL TCI states can be activated via MAC-CE-based TCI state activation   * When joint TCI states are activated, only joint TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication   + Here, ~~all the activated~~ only TCI states ~~are~~ corresponding to joint TCI ~~states~~ are activated. * When separate DL/UL TCI states are activated, either DL-only TCI state, UL-only TCI state, or DL+UL TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication   + Here ~~all the activated~~ only TCI states ~~are~~ corresponding to separate DL/UL TCI ~~states~~ are activated. * Detailed MAC-CE-based design on how to activate either only joint DL/UL TCI states or only separate DL/UL TCI states is up to RAN2   [Mod: Agree this wording is clearer since that term was never defined before, done] |
| Mod V20 | Revised proposals to address the above inputs  **Please check the latest version of FL proposals** |
| Lenovo/Motorola Mobility | Proposal 3.1: OK  Proposal 3.2: Support  Proposal 3.3: We think it is not necessary to have such limit. It is possible to assign separate TCI codepoint with MAC-CE to have a mixture of joint TCI and separate DL only, UL only, or UL+DL TCI, as long as all these TCI codepoints can fit into the 8 TCI states. |
| MediaTek | P3.1: Support the proposal with Samsung’s suggestion  P3.2: Support. Regarding the issue for further study, we think it is not only limited to additional offset, but also how to define the application time for CCs with different SCSs. Meanwhile, we think application time for common TCI state ID update across a set of configured CCs is also important. Thus, we suggest the change:   * FFS: Application time and whether additional offset is needed for the application time ~~of~~ for cross carrier beam indication ~~is needed~~ and common TCI state ID update across a set of configured CCs if CCs have different SCSs   P3.3: Following the suggestion from Samsung, it would be better to revise the proposal as follows:  **Proposal 3.3**: On Rel-17 unified TCI, for a UE configured with both joint TCI and separate DL/UL TCI (including DL-only TCI, UL-only TCI, or DL+UL TCI), TCI states can be activated via MAC-CE-based TCI state activation for either only joint DL/UL TCI ~~states~~ or only separate DL/UL TCI ~~states can be activated via MAC-CE-based TCI state activation~~   * When ~~joint~~ TCI states are activated for joint DL/UL TCI, only joint TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication   + Here, only TCI states corresponding to the joint TCI are activated. * When ~~separate DL/UL~~ TCI states are activated for separate DL/UL TCI, either DL-only TCI ~~state~~, UL-only TCI ~~state~~, or DL+UL TCI ~~state~~ can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication   + Here, only TCI states corresponding to the separate DL/UL TCI are activated * Detailed MAC-CE-based design on how to activate either only joint DL/UL TCI ~~states~~ or only separate DL/UL TCI ~~states~~ is up to RAN2 |
| Ericsson | P3.1: We think this is unnecessarily complex: it is highly unlikely that “UL-only” or “DL-only” is ever implemented. But we are ok for progress.  P3.2: Support  P3.3: Same comment as for P3.1. |
| CMCC | Proposal 3.1~3.3: Support |
| Nokia/NSB | Proposal 3.3: looking at other companies’ comments, we do not agree with the direction of this agreement. In general we are not supportive to design separate operation within unified framework. If the unified TCI framework is going to fork in UE-feature-like support for joint and separate, we think this is a big drawback and not what was intended when this discussion started, that is a lean TCI framework. Indeed, the outcome of such “multi-mode” operation is worse than rel15/16, UE vendors will start “selecting” which mode they operation, that is joint OR separate, while on the network side we need to implement both! With such a potential outcome is not clear at all what are the benefits of the two ways of signaling? In addition, we should also discuss how many states are we going to use, are they going to be more than 8 states? Some of the signaling variants might make more sense than others when also knowing exactly how many states we are using. We think the starting point of this signaling should be that joint and separate are mapped in the same set of codepoints, are these not sufficient as a very first shot of Rel17? As an ultimate alternative, if companies insist of having joint or separate indication, we should take the temperature of what is the support of an independent operation for the two modes and decide which one to pick. We will be very much supportive of the option getting more support, but in any case, we should not continue with this dual track. |
| Qualcomm | Proposal 3.1: OK  Proposal 3.2: Suggest in the 1st sub-bullet to clarify that … UE capability, “which should be at least X ms or Y symbols”.  Proposal 3.3: OK |

### Issue 4 (MP-UE)

Table 7 Summary: issue 4

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| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 4.1 | Whether to support the following measurement/reporting scheme for UE-initiated panel activation/selection:   * Opt1-1: A panel entity corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance   + The correspondence between a panel entity and a reported CSI-RS and/or SSB resource index is informed 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) * Opt1-2: A panel entity is referring to a new panel ID within CSI/beam reports   + FFS: Detailed design of the new panel ID including the information conveyed by the new panel ID   + Note: The association between the new panel ID and the panel entity is determined by the UE * Opt1-3: No additional specification support | **Opt1-1:** Huawei, HiSi, Apple (if capable), Sony (2nd pref), MTK, APT/FGI (2nd preference)  **Opt1-2:** IDC, vivo, Lenovo/MoM, Spreadtrum, CMCC, Samsung (resource set ID), ZTE (global ID), Huawei, HiSi, Sony, Fraunhofer IIS/HHI, Xiaomi, AT&T, NTT Docomo, LGE  **Opt1-3:** CATT, OPPO, Ericsson, Apple, APT/FGI (1st preference), Intel |
| 4.2 | Whether to support CB-based SRS resources with different numbers of ports | **Yes**: ZTE, Samsung, CATT, OPPO (different sets have different number of ports), Qualcomm, NTT Docomo, LGE, MTK  **No**: vivo, APT/FGI, Intel |
| 4.3 | Whether to support NCB-based SRS resource sets with different numbers of resources | **Yes**: ZTE, Samsung, CATT  **No**: |
| 4.4 | Support of NW-initiated panel activation/selection | **Yes**: IDC (TCI state group indication + gNB confirmation), vivo (TCI state update), Huawei, HiSi (handshake), Qualcomm (handshake), Fraunhofer IIS/HHI , Xiaomi( only NW-initiated panel selection)  **No**: Spreadtrum, Sony, Xiaomi(not support NW-initiated panel activation), OPPO, CATT |
|  |  |  |

The following observation can be made:

* (4.1) Opt1-2 represents the super-majority view
* (4.2) The additional support for having different # ports for SRS resources represents the majority view

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

**Proposal 4.1**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection, at least one panel entity is referring to a panel ID within a CSI/beam reporting instance

* The panel ID(s) within CSI/beam reporting instance is determined by the UE and reported to NW
  + FFS: Details for reporting the panel ID(s) within a CSI/beam reporting instance
* The panel ID(s) is used to convey at least the following information:
  + A panel active state either DL reception only or both DL reception and UL transmission
  + Other information is not precluded
* FFS: Detailed design of the panel ID
* Note: The association between the panel ID and the panel entity is determined by the UE

**Proposal 4.2**: Support configuring a UE with two SRS resource sets having different numbers of ports for codebook-based UL transmission

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** |
| Nokia/NSB | Proposal 4.2: Support. Can we clarify that SRS resources within the same resource set can have different number of ports?  **Proposal 4.2**: Support configuring a UE with SRS resources having different numbers of ports within the same resource set for codebook-based UL transmission  [Mod: please check revised version which may address your comments] |
| Qualcomm | For Proposal 4.1: Suggest to add the following FFS  FFS: Details for reporting the new panel ID within CSI/beam reports.  For Proposal 4.2: Support  [Mod: done] |
| Apple | Do not support proposal 4.1 and 4.2.  Proposal 4.1 and 4.2 prohibits flexibility for UE to change panel at any time. |
| Samsung | Proposal 4.1: Support  Proposal 4.2: Support |
| MediaTek | P4.1: We have concern on Opt1-2. For Opt1-2, if a new panel ID is associated with a beam reporting, which means UE can only initiate one UE panel for that beam reporting. If NW would like to check the link qualities from multiple UE panels, multiple beam reports with different IDs have to be configured. We fail to see why separate reports are needed for each UE panel. Furthermore, if multiple CSI/beam reports with different IDs are configured to UE, UE is required to initiate multiple UE panels, which is not aligned with the spirit of “UE-initiated” panel activation and election. In our opinion, for Opt1-1, only one beam report is needed since SSBRSs/CRIs can correspond to one or multiple UE panels, and UE can decide to activate how many UE panels.  To address the comments from Apple, Qualcomm and MediaTek, suggest the following changes to the proposal:   * Allow UE to determine new panel ID and inform to NW per reporting instance. UE can change the panel across different reporting instances. Details for reporting the new panel ID(s) within a CSI/beam reporting instance can be further discussed, as suggested by Qualcomm. * Allow one or more activated panels per reporting instance, instead of only one. * Clarify what information is conveyed by new panel ID in this proposal. If no information is conveyed by new panel ID, the need to introduce such ID in specification is unclear. At least we see a panel active state should be supported for the case if UL panel(s) are not the same set of DL panel(s), as agreed in previous RAN1 meeting. Other information is not precluded.   **Proposal 4.1**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection, at least one panel entity is referring to a new panel ID within a CSI/beam reporting instance   * The new panel ID(s) within CSI/beam reporting instance is determined by the UE and reported to NW   + FFS: Details for reporting the new panel ID(s) within a CSI/beam reporting instance * The new panel ID(s) is used to convey at least the following information:   + A panel active state either DL reception only or both DL reception and UL transmission   + Other information is not precluded * FFS: Detailed design of the new panel ID * Note: The association between the new panel ID and the panel entity is determined by the UE   [Mod: Done]  P4.2: Support |
| OPPO | Proposal 4.1: do not support. We do not see the need for specification support  Proposal 4.2: we support to configure two SRS resource set with different number of antenna ports for CB. Suggest to change the proposal as follows:  **Proposal 4.2**: Support configuring a UE with two SRS resource sets having different numbers of ports for codebook-based UL transmission  [Mod: agree, done] |
| ZTE | Proposal 4.1 Support. We think that we need to make final decision this meeting, otherwise to be honest, we do not think that we can have sufficient time budget/meetings for complete this issue 4 MPUE.  Proposal 4.2: OPPO’s update is better in our views, and we also support to extend this issue to NCB case, e.g., two SRS resource sets that may have same or different numbers of SRS resources. |
| LG | Support Proposal 4.1 and 4.2  On Proposal 4.1, prerequisite for this proposal would be a UE report regarding the number of DL/UL panel entities accompanied by their properties. Essential information for gNB would be whether reported CRI/SSBRI is measured from DL only panel or from DL/UL shared panel. If it is from DL only panel, gNB can use the CRI/SSBRI as DCI TCI but not for UL TCI, otherwise it can use it for both DL TCI and UL TCI. Thus, it would be good to add ‘UE capability report on panel-specific information is supported including at least supported number of DL/UL panel IDs’ as a subbullet.  On Proposal 4.2, detailed signaling can be discussed later (e.g. different number of ports within a same resource set as Nokia or across different resource sets as OPPO). |
| Xiaomi | Proposal 4.1, support  Proposal 4.2, support |
| NTT Docomo | Support proposal 4.1 and proposal 4.2. |
| Fraunhofer IIS/HHI | Support proposal 4.1  Proposal 4.2: Agree in principle. The proposal is still unclear if the difference in number of ports is between different SRS resources in a set or between resources in different SRS resource sets. |
| CATT | Proposal 4.1: Do not support. We don’t see a strong need for specification non transparent support of these identifiers.  Proposal 4.2: Support. |
| Mod V16 | Revised proposals 4.1 and 4.2 to address the above inputs  **Please check the latest version of FL proposals** |
| vivo | Fine with the current formulation of proposal 4.1 and proposal 4.2. |
| Samsung2 | For proposal 4.1, we would like to replace “new panel ID” with “ID”.  [Mod: Removing “new” is fine, but removing “panel” makes the proposal ambiguous. Since this proposal is about an ID for a panel entity, including “panel” gives a better functional description at this early stage. It is understood that “panel” is not a spec term, however.  I removed “new” but not “panel”] |
| Mod V20 | Revised proposals 4.1 and 4.2 to address the above inputs  **Please check the latest version of FL proposals** |
| Lenovo/Motorola Mobility | Proposal 4.1: Support  Proposal 4.2: Support |
| MediaTek | Proposal 4.1: Support  We see current specification cannot support UE-initiated UL panel activation and selection at least for the following agreed use cases:   * Different configurations across UE panels * UE power saving * Multiple activated UE panels for e.g., MPE mitigation   In order to support above use cases, NW needs to know some panel-related information of the activated UE panel(s). For example:   * To support different configurations across panels or UE power saving, the panel-specific configuration/ capability like the supported maximum number of ports/layers on each activated panel has to be known by NW. Then, NW can trigger SRS transmission and schedule PUSCH with a corresponding number of ports/layers on the UL panel selected by UE. * To support multiple activated panels for MPE mitigation, the panel selection status of each activated panel (e.g. active state for both DL and UL or active state for DL only) has to be known by NW. Then, NW can schedule UL transmission on the UE-selected UL panel.   In our view, panel ID can be used as an implicit way to report panel-related information of the activated panel(s) to NW but without disclosing UE antenna (group) implementation, similar to TCI state used for beam indication without disclosing NW beamforming implementation.  Proposal 4.2: Support |
| Ericsson | P4.1: Do not support. The panel ID would turn the UE into multiple UEs that can potentially be separately scheduled, and so far we have not seen any motivation why reference signals cannot be used instead of panel IDs.  P4.2: Do not support. Use case is unclear  P4.3: Do not support. Use case is unclear  P4.4: Do not support. Up to the UE to activate panels. |
| CMCC | Proposal 4.1: Support.  Proposal 4.2: Support. In our view, specification support is needed to facilitate gNB and UE have the same knowledge of the DL Rx panel(s) and UL Tx panel(s). |
| Nokia/NSB | Proposal 4.1: Do not support. The grouping concept can very much have the same functionality at the panel ID mentioned in this agreement.  Proposal 4:2: OK. |
| Qualcomm | Proposal 4.1: OK  Proposal 4.2: OK, but need to clarify if the resources in the same set can have different port number or not? |

### Issue 5 (MPE mitigation)

Table 9 Summary: issue 5

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| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 5.1 | Whether to support:   * Opt 1A. {Rel.16 P-MPR based (beam/panel-level)} + Virtual PHR or a modified version   + The modified version may be associated with each activated UL TCI or, if applicable, joint TCI, or associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) from candidate pool, if reported.   + The reporting reuses the event-driven mechanisms from the Rel-16 P-MPR reporting * Opt 1D. {Rel.16 P-MPR based (beam/panel-level)}   + The reporting reuses the event-driven mechanisms from the Rel-16 P-MPR reporting * Opt 2A. {SSBRI(s)/CRI(s) and/or panel indication} + L1-RSRP [L1-SINR] or a modified version that accounts for MPE effect associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured)   + FFS: Whether the reporting is UE-initiated (event-driven) and/or NW-initiated   + FFS: If Opt2A is selected and there is no consensus on a modified L1-RSRP definition, at least the Rel-15 L1-RSRP definition is reused and virtual PHR may be added | **Option 1A**: ZTE, Lenovo/MoM, Apple, OPPO (via MAC CE), Qualcomm, Nokia/NSB, MTK, Convida, NTT Docomo  **Option 1D**: vivo (add panel ID in PHR MAC CE), Spreadtrum, Huawei, HiSi, Sony, Xiaomi  **Option 2A**: CATT, Apple, Sony, Lenovo/MoM, CMCC, Samsung, Qualcomm, Nokia/NSB, MTK, NTT Docomo, LGE, Ericsson |
| 5.2 | If Opt1A/D in 5.1 is supported:   * Alt1. Beam-level reporting * Alt2. Panel-level reporting | **Alt1**: Qualcomm, Nokia/NSB, Convida, MTK, Intel, ZTE(1st preference)  **Alt2**: vivo, Spreadtrum, Huawei, HiSi, Xiaomi, Sony, NTT Docomo, ZTE(2nd preference) |
| 5.3 | If Opt2A in 5.1 is supported:   * Alt1 (beam-level): Reporting of at least SSBRI(s)/CRI(s) to indicate gNB beam(s) that is feasible for UL transmission * Alt2 (panel-level): Reporting of at least an indicator associated with a UE ‘panel’ that is feasible for UL transmission | **Alt1**: CATT, Nokia/NSB, Intel, ZTE, NTT Docomo,  **Alt2**: Lenovo/MoM, Samsung, LG |
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The following observation can be made:

* (5.1) Opt2A represents the majority view, followed by Opt1A

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

**Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation, support the following schemes:

* Opt1A. {Rel.16 P-MPR based} + Virtual PHR or a modified version
  + The modified version may be associated with each activated UL TCI or, if applicable, joint TCI, or associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) from candidate pool, if reported.
  + The reporting reuses the event-driven mechanisms from the Rel-16 P-MPR reporting
  + FFS: Definition of virtual PHR and how it is used
* Opt2A. {SSBRI(s)/CRI(s)} + L1-RSRP [L1-SINR] reporting (on PUSCH/PUCCH) or a modified version that accounts for MPE effect associated with each of the reported SSBRI(s)/CRI(s)
  + FFS: Whether the reporting is UE-initiated (event-driven) and/or NW-initiated
  + FFS: If Opt2A is selected and there is no consensus on a modified L1-RSRP definition, at least the Rel-15 L1-RSRP definition is reused and virtual PHR may be added
  + FFS: Depending on the outcome of issue 4 (MPUE), whether an indicator associated with ‘panel entity’ (term used for discussion) is also included
  + FFS: When multiple SSBRIs/CRIs and their corresponding metrics are reported in the same reporting instance, whether to allow mixture between the SSBRI(s)/CRI(s)) intended for MPE mitigation and for DL beam reporting

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 in principle. But prefer to support Opt2A as NW-initiated since event-driven mechanism is already supported by Opt1A, and Opt2A can be an enhanced beam reporting format. We don't see the need to introduce two schemes with the same reporting types.  [Mod: Let’s take a baby step first for Opt2A ☺] |
| Nokia/NSB | Support in principle |
| Qualcomm | Support as a starting point |
| Apple | Support |
| Samsung | Support as a compromise |
| OPPO | Ok in principle. Suggest to remove the wording “beam” and “panel” because in the spec, we eventually use the RS ID or TCI state for those reports and there will be no beam or panel in the spec.  **Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation, support the following schemes:   * Opt1A. {Rel.16 P-MPR based ~~(beam/panel-level)~~} + Virtual PHR or a modified version   + The modified version may be associated with each activated UL TCI or, if applicable, joint TCI, or associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) from candidate pool, if reported.   + The reporting reuses the event-driven mechanisms from the Rel-16 P-MPR reporting * Opt2A. {SSBRI(s)/CRI(s) ~~and/or panel indication~~} + L1-RSRP [L1-SINR] or a modified version that accounts for MPE effect associated with each of the reported SSBRI(s)/CRI(s) ~~and/or panel indication (if configured)~~   + FFS: Whether the reporting is UE-initiated (event-driven) and/or NW-initiated   + FFS: If Opt2A is selected and there is no consensus on a modified L1-RSRP definition, at least the Rel-15 L1-RSRP definition is reused and virtual PHR may be added   [Mod: Agree, done. Added an FFS just to prevent (many) panel ID proponents from feeling excluded ☺] |
| ZTE | Support as a compromise.  Just to clarify our preference: if Alt-2 is supported, we think that it should be NW-initialized and be performed based on Rel-15 L1-RSRP + virtual PHR rather than a modified definition.  [Mod: We keep this in mind for the next step] |
| LG | Support as a starting point |
| NTT Docomo | Support proposal 5.1. |
| CATT | Support proposal 5.1. |
| Mod V16 | Revised proposal per OPPO’s input  **Please check the latest version of FL proposals** |
| vivo | Regarding Option2A, would like to understand whether the L1-RSRP is reported in layer 1?  [Mod: Done. Based on the Tdocs, yes it is reported just as the regular L1-RSRP (on PUCCH or PUSCH)]  Regarding Option1A, would like to understand how the virtual PHR is defined? How they would be used?  [Mod: FFS is added] |
| Samsung2 | Suggest to add the following FFS bullet in Opt2A (from last meeting agreement):  o FFS: When multiple SSBRIs/CRIs and their corresponding metrics are reported in the same reporting instance, whether to allow mixture between the SSBRI(s)/CRI(s)) intended for MPE mitigation and for DL beam reporting  [Mod: Done] |
| Mod V20 | Revised proposal based on inputs  **Please check the latest version of FL proposals** |
| Lenovo/Motorola Mobility | Support in principle |
| MediaTek | Support |
| Ericsson | We would be OK with the following modification:  **Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation, support the following schemes:   * Opt1A. {Rel.16 P-MPR based} + Virtual PHR or a modified version   + The modified version may be associated with each activated UL TCI or, if applicable, joint TCI, or associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) from candidate pool, if reported.   + The reporting reuses the event-driven mechanisms from the Rel-16 P-MPR reporting   + FFS: Definition of virtual PHR and how it is used * Opt2A. {SSBRI(s)/CRI(s)} + L1-RSRP [L1-SINR] reporting (on PUSCH/PUCCH) or a modified version that accounts for MPE effect associated with each of the reported SSBRI(s)/CRI(s)   + The reporting is NW-initiated.   + FFS: Whether to additionally support UE-initiated (event-driven) reporting   + FFS: If Opt2A is selected and there is no consensus on a modified L1-RSRP definition, at least the Rel-15 L1-RSRP definition is reused and virtual PHR may be added   + FFS: Depending on the outcome of issue 4 (MPUE), whether an indicator associated with ‘panel entity’ (term used for discussion) is also included   + FFS: When multiple SSBRIs/CRIs and their corresponding metrics are reported in the same reporting instance, whether to allow mixture between the SSBRI(s)/CRI(s)) intended for MPE mitigation and for DL beam reporting   Just as we remarked in the TDoc, it should be possible to operate under additional power backoff conditions for some time and having beam management solutions that are similar to the currently specified mechanisms would be crucial. Relying only on UE-initiated reporting is not an option. |
| CMCC | Support |
| vivo | Sorry if there is any misunderstanding and not make my original comments clear.  We have strong concerns on current formulation.  For Option2Awith the layer 1 report, this would create additional power consumption from UE perspective. MPR event typically happens at seconds level, but layer1 report is at millisecond level. It means UE would need to keep sensor on all the time. This is not acceptable from UE perspective. |
| Nokia/NSB | OK |
| Qualcomm | For Proposal 5.1, OK |

### Issue 6 (advanced beam refinement/tracking)

Table 11 Summary: issue 6

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| **#** | **Issue** | **Companies’ views on specific candidate schemes** |
| 6.1 | Group 1: Beam management with reduced DL signaling to reduce latency   * Opt 1-1A: Beam measurement/reporting/refinement/selection triggered by beam indication (without CSI request) * Opt 1-1B: UE-initiated beam selection/activation based on beam measurement and/or reporting (without beam indication or activation from NW) * Opt 1-2: Semi-static NW-configured beam selection (without beam indication and measurement/reporting) * Opt 1-3: SSB grouping to reduce beam training * Opt 1-4: Aperiodic beam measurement/reporting based on multiple resource sets for reducing beam measurement latency | **Opt 1-1A**: IDC, Nokia/NSB (refinement), OPPO, Samsung (refinement, M/R)  **Opt 1-1B**: IDC (with beam group indication), Nokia/NSB, Futurewei, Ericsson, OPPO, MTK, LG, NTT Docomo  **Opt 1-2**: NTT Docomo  **Opt 1-3**: Apple, Ericsson  **Opt 1-4**: Nokia/NSB (BFR), ZTE, Samsung |
| 6.2 | Group 2: Reducing activation delay of TCI states and PL-RSs (including other WGs, e.g. RAN4)   * Opt 2-1A: Latency reduction for MAC CE based TCI state activation, or frequency/time/beam tracking * Opt 2-1B: Latency reduction for MAC CE based PL-RS activation * Opt 2-1C: Latency reduction for MAC CE based PUCCH resource/resource group activation * Opt 2-2: Direct SCell TCI state activation * Opt 2-3: Replacing RRC-based with MAC CE (or DCI) based for DL QCL or UL information update * Opt 2-4: One-shot timing update for TCI state update   Note: A number of companies argued that most of the schemes in this category can be handled exclusively in RAN4 | **Opt 2-1A**: vivo (A-TRS), Ericsson, ZTE, Apple (AP CSI-RS triggering via MAC CE/DCI), NTT Docomo  **Opt 2-1B**: vivo, ZTE  **Opt 2-1C**: vivo   * Other views: Ericsson (under issue 1)   **Opt 2-2**: Qualcomm   * Other views: Ericsson (out of scope, CA AI)   **Opt 2-3**: IDC, Lenovo/MoM (associated CSI-RS for SRS resource for NCB)   * Other views: Ericsson (unclear target)   **Opt 2-4**: Ericsson |

The following observation can be made:

* (6.1, 6.2) Opt1-1B and Opt 2-1A represent the majority views for Group 1 and 2, respectively. Note that the agreement says “strive for at most one per group”

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

**Proposal 6.1**: On Rel.17 enhancements to facilitate advanced beam refinement/tracking, focus study (including down-selection) and, if needed, specification effort on the following options:

* Group 1:
  + Opt A. UE-initiated beam selection/activation based on beam measurement and/or reporting (without beam indication or activation from NW)
  + Opt B. Beam measurement/reporting/refinement/selection triggered by beam indication (without CSI request)
* Group 2: Latency reduction for MAC CE based TCI state activation, or frequency/time/beam tracking

Table 12 Additional inputs: issue 6

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 12**  **2) Share your inputs on the above FL proposals** |
| MediaTek | Support the proposal  For G1, we see UE-initiated beam selection/activation could be one alternative to reduce the beam activation latency. Based on beam measurements, UE can select one (i.e., beam selection) or more (i.e., beam activation) TCI states as active and reports it/them to NW. Since the TCI state(s) is selected/activated by UE, UE is responsible to remember the QCL properties of DL RS(s) associated with the selected/activated TCI state(s). Thus, the one SSB measurement for beam activation is not needed anymore. Once NW response to the report is received by UE, the selected/activated TCI states can be immediately used for DL reception (or UL transmission in unified TCI framework). |
| Qualcomm | Support |
| Apple | Support in principle. One quick question for clarification, for group 1, is it correct understanding that PRACH like beam report is not precluded? |
| Samsung | Not support   * FL proposal for Group 1 is too premature since we haven’t even listed the pros and cons of each scheme. In fact, the benefit of opt 1-1B over beam indication based scheme is unclear. Without gNB confirmation we have misalignment, and with gNB confirmation there is no latency/overhead saving from beam indication based beam selection (at the expense of more spec impact).   [Mod: From FL perspective, unless we narrow things down at this stage, the chance of having any support for issue 6 in Rel-17 is zero. I added 1-1A (the second most popular scheme, it seems).]   * For group 2, Samsung believes this is something to be discussed in RAN4, not in RAN1. So the second bullet from FL proposal is not needed and should be removed.   [Mod: Even if this is to start in RAN4, an LS to RAN4 seems to be necessary to start some discussion there. The purpose of this proposal is for that. Otherwise RAN4 wouldn’t know what to do] |
| ZTE | We support second bullet (Group-2), but not for first bullet (Group-1).  In our views, the FL proposal for Group 1 should be well justified firstly due to that, from gNB perspective, we can NOT live with a solution of totally up to UE reporting without any gNB confirmation that seems to reverts the basic assumption for UE-initialized behavior, e.g., for BFR, in 3GPP 5G-NR. If with gNB confirmation, we are wondering the benefits compared with the normal procedure of beam indication/activation and reporting.  [Mod: This is a valid point which can be further discussed when studying the candidates. Note that the proposal is not for support, but for focusing study to limit the scope ] |
| LG | Support |
| NTT Docomo | Support. |
| Mod V15 | Revised proposal to address concern from Samsung by adding one more candidate for Group 1. But I still believe the 2nd bullet for Group 2 is needed, e.g. for LS to RAN4.  **Please check the latest version of FL proposals** |
| Samsung2 | For group A, we are fine to further analyze and study the pros and cons of OptA and OptB for down selection.  [Mod: Done]  For group B, if the purpose is to send LS to RAN4, shouldn’t we include all the options and let RAN4 comment on the options and do down selection  [Mod: This is one possibility of course. But my concern is that RAN4 will be confused with the long list. From FL perspective, it is better to narrow down the list, or best to choose one. I am leaving it as is for now since only Samsung voices concern on this issue.] |
| Mod V20 | Slight revision.  **Please check the latest version of FL proposals** |
| Ericsson | We agree with Samsung that we should strive to include more than one item from group 2 in a RAN4 LS. |
| Nokia/NSB | OK |
| Qualcomm | If we include two options in Group 1, can we also include PL RS in group 2? This is similar to TCI state and is more critical to fix to our understanding, since there is zero description on the application time for the PL RS not maintained by UE before. Also, PL RS is supported by at least 3 companies without concerning company so far.   * Group 2: Latency reduction for MAC CE based TCI state and PL RS activation, or frequency/time/beam tracking |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | R1-2105296 | Moderator summary for offline discussion on multi-beam enhancement: CA QCL and unified TCI for 'other signals/channels' | Moderator (Samsung) |
| 2 | R1-2104205 | Enhancement on multi-beam operation | FUTUREWEI |
| 3 | R1-2104266 | Enhancements on multi-beam operation | Huawei, HiSilicon |
| 4 | R1-2104292 | Remaining Issues on Rel-17 Multi-beam Operation | InterDigital, Inc. |
| 5 | R1-2104343 | Further discussion on multi beam enhancement | vivo |
| 6 | R1-2104404 | Enhancements on Multi-beam Operation | Lenovo, Motorola Mobility |
| 7 | R1-2104411 | Enhancements on Multi-beam Operation | Spreadtrum Communications |
| 8 | R1-2104484 | Enhancements on multi-beam operation | CATT |
| 9 | R1-2104585 | Enhancements on Multi-beam Operation | ZTE |
| 10 | R1-2104599 | Enhancements on multi-beam operation | CMCC |
| 11 | R1-2104654 | Enhancements on Multi-beam Operation | Qualcomm Incorporated |
| 12 | R1-2104732 | Enhancements on Multi-beam Operation | OPPO |
| 13 | R1-2104888 | Enhancements to Multi-Beam Operations | Intel Corporation |
| 14 | R1-2105058 | Enhancements on Multi-beam Operation | Fujitsu |
| 15 | R1-2105087 | Views on Rel-17 Beam Management enhancement | Apple |
| 16 | R1-2105151 | Further enhancement on multi-beam operation | Sony |
| 17 | R1-2105231 | Enhancements on multi-beam operation | Fraunhofer IIS, Fraunhofer HHI |
| 18 | R1-2105246 | Discussion on multi-beam operation | NEC |
| 19 | R1-2105273 | Enhancements on Multi-beam Operation | Nokia, Nokia Shanghai Bell |
| 20 | R1-2105291 | Multi-Beam Enhancements | Samsung |
| 21 | R1-2105353 | Enhancement on multi-beam operation | MediaTek Inc. |
| 22 | R1-2105540 | Enhancements on multi-beam operation | Xiaomi |
| 23 | R1-2105588 | Enhancements on Multi-beam Operation | Convida Wireless |
| 24 | R1-2105665 | Enhancements on Multi-Beam Operations | AT&T |
| 25 | R1-2105683 | Discussion on multi-beam operation | NTT DOCOMO, INC. |
| 26 | R1-2105779 | Enhancements on Multi-beam Operation | LG Electronics |
| 27 | R1-2105816 | Discussion on enhancements for Multi-beam Operation | Asia Pacific Telecom, FGI |
| 28 | R1-2105828 | Enhancements on Multi-beam Operation | Ericsson |
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