**3GPP TSG RAN WG1 #106-e R1-2106864**

**e-Meeting, August 16th – 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:

|  |
| --- |
| 1. Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:    1. Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management for intra-cell and inter-cell scenarios to support higher UE speed and/or a larger number of configured TCI states:       1. Common beam for data and control transmission/reception for DL and UL, especially for intra-band CA       2. Unified TCI framework for DL and UL beam indication       3. Enhancement on signaling mechanisms for the above features to improve latency and efficiency with more usage of dynamic control signaling (as opposed to RRC)       4. For inter-cell beam management, a UE can transmit to or receive from only a single cell (i.e. serving cell does not change when beam selection is done). This includes L1-only measurement/reporting (i.e. no L3 impact) and beam indication associated with cell(s) with any Physical Cell ID(s)          1. The beam indication is based on Rel-17 unified TCI framework          2. The same beam measurement/reporting mechanism will be reused for inter-cell mTRP          3. This work shall only consider intra-DU and intra-frequency cases    2. Identify and specify features to facilitate UL beam selection for UEs equipped with multiple panels, considering UL coverage loss mitigation due to MPE, based on UL beam indication with the unified TCI framework for UL fast panel selection |

This summary includes the following:

* Observation and proposal
* Summary of current companies’ positions on each of the aspects within the category

## Summary of companies’ inputs

The listed issues are structured primarily to facilitate some progress on pending issues identified in the agreements (see Appendix A).

### Issue 1 (Rel.17 unified TCI framework – note: for intra-cell beam management)

Table 1 Summary: issue 1

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 1.1 | Confirm WA on CA and potential refinement  **Working Assumption**  For common TCI state ID update and activation to provide common QCL information at least for UE-dedicated PDCCH/PDSCH and/or common UL TX spatial filter(s) at least for UE-dedicated PUSCH/PUCCH across a set of [configured] CCs/BWPs:   * RRC-configured TCI state pool(s) can be configured in the PDSCH configuration (*PDSCH-Config*) for each BWP /CC as in Rel-15/16   + Note: Such RRC-configured TCI state pool(s) configuration doesn’t imply that separate DL/UL TCI state pool is excluded or supported * RRC-configured TCI state pool(s) can be absent in the PDSCH configuration (*PDSCH-Config*) for each BWP/CC, and replaced with a reference to RRC-configured TCI state pool(s) in a reference BWP/CC   + In the PDSCH configuration (*PDSCH-Config*) of the reference BWP/CC, RRC-configured TCI state pool(s) shall be configured   + For a BWP/CC where the PDSCH configuration contains a reference to the RRC-configured TCI state pool(s) in a reference BWP/CC, the UE applies the RRC-configured TCI state pool(s) in the reference BWP/CC * When the BWP/CC ID (*cell*) for QCL-Type A/D source RS in a *QCL-Info* of the TCI state is absent, the UE assumes that QCL-Type A/D source RS is in the BWP/CC to which the TCI state applies * Introduce a UE capability to report maximum number of TCI state pools it can support across BWPs and CCs in a band, and the candidate value at least includes 1 * FFS: Introduce a UE capability to report maximum number of configured TCI states that it can support across BWPs and CCs in a band * FFS: How to define reference BWP/CC | **Confirm WA:** ZTE, vivo, Lenovo/MotM, Spreadtrum, Sony, Samsung, OPPO (with changes), FGI/APT, MTK (with changes), Ericsson (with changes), Apple (with changes), NTT Docomo (with changes), Xiaomi, CATT  Changes:   * [configured]   + **Keep**: MTK   + **Remove**: ZTE, Samsung, Apple, MTK (if the whole sentence related to “common TCI indication and activation” is removed as well) |
| 1.2 | Additional type(s) of target RS sharing the same TCI state as UE-dedicated PDSCH/CORESET or UE-dedicated PUSCH/PUCCH   * Whether each of the following DL RSs can share the same indicated 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   + DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs * Whether some SRS resources or resource sets for BM can share the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC   **Note: also discussed offline [1] section 1** | CSI-RS resources for CSI   * Yes (22): Lenovo/MotM, Spreadtrum, Samsung, NEC, OPPO, FGI/APT, CMCC, Fraunhofer IIS/HHI, Intel, AT&T, Convida, Nokia/NSB, Ericsson, Qualcomm, IDC, Xiaomi, CATT, Sony, ZTE (for aperiodic only) * No (5): vivo, MTK, Huawei/HiSi, Futurewei   **Some** CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)   * Yes (15): Sony (rep ON), Samsung (rep ON), OPPO (rep ON), FGI/APT, CMCC (rep ON), Fraunhofer IIS/HHI, Intel (repetition ON), AT&T, ZTE (for aperiodic only), Ericsson (if TCI state is not configured), Xiaomi (rep ON), Fujitsu, LG * No (7): vivo, Spreadtrum, MTK, IDC, Huawei/HiSi, Futurewei, CATT (rep ON)   CSI-RS for tracking   * Yes (9): Lenovo/MotM, Sony, OPPO, Intel, AT&T, Nokia/NSB, Qualcomm, CATT * No (6): vivo, Spreadtrum, MTK, Huawei/HiSi, Futurewei   Aperiodic CSI-RS (for CSI and BM):   * Yes (7): Apple, Ericsson, OPPO (but not all), Sony, ZTE, MTK, Intel * No (3): Huawei/HiSi, Futurewei   DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs   * Yes (10): ZTE, Fraunhofer IIS/HHI, AT&T, Nokia/NSB, Apple, Qualcomm, MTK, Samsung * No (2): vivo, Futurewei   Some SRS resources or resource sets for BM   * Yes (11): Spreadtrum, Sony, Intel, Nokia/NSB, FGI/APT, Lenovo/MotM, Samsung, LG, ZTE (support beam refinement) * No (6): Huawei/HiSi, vivo, MTK, Futurewei, IDC |
| 1.3 | TCI signaling/configuration mechanism for DL RS not sharing the same TCI state as UE-dedicated PDSCH/CORESET or UE-dedicated PUSCH/PUCCH   * Alt1. Rel-15/16 TCI state update signaling/configuration mechanism(s) are reused to update/configure the Rel-17 TCI state * Alt2. Rel-17 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: also discussed offline [1] section 1** | **Alt1 Rel-15/16 (20):** Samsung, Fujitsu, NEC, OPPO, Qualcomm, Fraunhofer IIS/HHI, MTK, Ericsson, Xiaomi, Convida, Nokia/NSB, ZTE, IDC, CMCC, Huawei/HiSi, AT&T, LG  **Alt2 Rel-17 (8):** CATT, Intel, vivo, FGI/APT, Lenovo/MotM, Futurewei  **Avoid not sharing the same TCI state**: Apple |
| 1.4 | Finalizing PL-RS:   1. Definition of “beam misalignment or not” (between the DL source RS in the UL or (if applicable) joint TCI state to provide spatial relation indication and the PL-RS) 2. Detailed aspects of PL-RS e.g. CSI-RS type(s), restriction on configuration | 1.3.1:  When beam alignment is not supported:   * PL-RS = spatial ref RS: ZTE, vivo, Samsung, MTK * PL-RS and spatial ref RS share the same QCL-D SSB: Lenovo/MotM   1.3.2: ... |
| 1.5 | Finalizing UL PC parameters other than PL-RS:   1. If the setting of (P0, alpha, closed loop index) for SRS can also be associated with UL or (if applicable) joint TCI state. 2. Whether to configure the same setting of (P0, alpha, closed loop index) per TCI state across channels and apply a channel dependent component, or configure a channel dependent setting of (P0, alpha, closed loop index) per TCI state | 1.4.1:  **Yes:** ZTE, Lenovo/MotM (else use R15/16 method), Samsung, CATT, Ericsson, LGE, NTT Docomo, MTK, IDC, Sony, Intel  **No:** OPPO (configured per SRS resource)  1.4.2:  **Yes**: Samsung, LGE, NTT Docomo  **No:** ZTE, vivo, OPPO, MTK, Intel, Ericsson, IDC,CATT |
| 1.6 | Support for M>1 and/or N>1 for unified TCI framework in Rel-17 – in addition to M=1 and N=1   1. Use cases 2. Max values of M and/or N supported in Rel-17 3. Mechanism for beam indication and TCI state activation   **Note: also discussed offline [1] section 2** | 1.5.1:   * mTRP:   + **Yes**: ZTE (low priority), Samsung, Futurewei, NEC, OPPO, FGI/APT, CMCC, Fraunhofer IIS/HHI, MTK, Intel (mDCI only), AT&T, Xiaomi, Nokia/NSB, Apple, Qualcomm, NEC, Sony, IDC, vivo, Fujitsu, CATT, Lenovo/MotM, LG   + **No**: Ericsson, , Convida * sTRP:   + **Yes**: CATT, AT&T, IDC, vivo, IDC, LG   + **No**: Samsung (ok for Rel-18), MTK, Intel, ZTE * CORESET beam diversity:   + **Yes**: Futurewei, Qualcomm, Huawei/HiSi   + **No**: Samsung (ok for Rel-18), MTK, Intel * MPUE:   + Yes: LGE, IDC   + No: MTK, Intel   1.5.2:   * M=2, N=2: vivo, Samsung, NEC, OPPO, Nokia/NSB, MTK, IDC, Sony, FGI/APT, ZTE, CATT * M=1, N=1: Convida, Intel, NTT Docomo   1.5.3:   * One beam indication updates only one of the M or N TCI states (mDCI-based): Apple, Samsung, OPPO, NEC, Sony, MTK, FGI/APT, Xiaomi, CMCC, ZTE * One codepoint associated with M or N TCI states (sDCI-based): Lenovo/MotM, FGI/APT, Fraunhofer IIS/HHI, MTK, Apple, Qualcomm, NEC, AT&T, Futurewei, Sony,CATT * RRC-based grouping: Intel, Nokia/NSB, IDC, Fujitsu, LGE, CATT, FGI/APT |
| 1.7 | 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,CATT  **Alt2**: CMCC, Ericsson, Futurewei, Huawei/HiSi, Fraunhofer IIS/HHI, IDC, Sony |
| 1.8 | 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:** ZTE, Samsung, MTK * **No:** Spreadtrum, OPPO, Intel, Apple, Sony, Ericsson   SRS for BM, optionally with TRS as QCL Type-A source RS   * **Yes:** ZTE, IDC, Spreadtrum, Samsung, Convida, Nokia/NSB * **No:** Sony, OPPO, Fraunhofer IIS/HHI, MTK, Intel, Ericsson, LG   CSI-RS for CSI   * **Yes:** Sony, CMCC, Ericsson * **No:** Spreadtrum, Samsung, MTK, Apple, IDC |
|  |  |  |

The following observation can be made:

* 1.1: Some minor refinements to clarify the meaning were proposed to confirm the WA as an agreement. The phrase ‘[configured]’ was debated and does not seem essential.
* 1.2: Allowing CSI-RS for CSI (CSI acquisition typically assumes the same UE RX beam(s) as PDSCH), **some** CSI-RS for BM (for beam refinement, not for beam training), DMRS for non-UE-dedicated reception, **some** SRS resources for BM to share the same Rel-17 TCI state as dedicated UE reception/transmission represent super-majority view.
  + Note: Allowing implies that this is not always the case
* 1.3: Reusing the same signaling/configuration mechanism as Rel-15/16 represents the super-majority view – mainly motivated with minimizing spec work.
* 1.4: The definition of beam alignment needs to be first established. Based on the Tdocs, beam alignment can be defined based on the PL-RS or the source RS of the PL-RS
* 1.5: Extending the association to SRS represents the super-majority view (mainly to ensure ‘unified’ scheme for all the pertinent UL channels)

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

**Proposal 1.A**: On Rel.17 unified TCI framework, confirm the following working assumption as an agreement with a minor refinement highlighted in red

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

* RRC-configured TCI state pool(s) can be configured in the PDSCH configuration (*PDSCH-Config*) for each BWP/CC as in Rel-15/16
  + Note: Such RRC-configured TCI state pool(s) configuration doesn’t imply that separate DL/UL TCI state pool is excluded or supported
* RRC-configured TCI state pool(s) can be absent in the PDSCH configuration (*PDSCH-Config*) for each BWP/CC, and replaced with a reference to RRC-configured TCI state pool(s) in a reference BWP/CC
  + In the PDSCH configuration (*PDSCH-Config*) of the reference BWP/CC, RRC-configured TCI state pool(s) shall be configured
  + For a BWP/CC where the PDSCH configuration contains a reference to the RRC-configured TCI state pool(s) in a reference BWP/CC, the UE applies the RRC-configured TCI state pool(s) in the reference BWP/CC
* When the BWP/CC ID (i.e. *bwp-Id* or *cell*) for QCL-Type A/D source RS in a *QCL-Info* of the TCI state is absent, the UE assumes that QCL-Type A/D source RS is in the BWP/CC to which the TCI state applies
* Introduce a UE capability to report maximum number of TCI state pools it can support across BWPs and CCs in a band, and the candidate value at least includes 1
* FFS: Introduce a UE capability to report maximum number of configured TCI states that it can support across BWPs and CCs in a band
* FFS: How to define reference BWP/CC

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

* The following DL RSs can share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC
  + Some CSI-RS resources for CSI
    - FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic
    - Note: This doesn’t imply that all time-domain behaviors are automatically supported
  + Some CSI-RS resources for BM
    - FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic, repetition ‘ON’, apply to all resources in a set
    - Note: This doesn’t imply that all time-domain behaviors are automatically supported
  + DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs

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

* Some SRS resources or resource sets for BM can share the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC
  + FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic, apply to all resources in a set
  + Note: This doesn’t imply that all time-domain behaviors are automatically supported

**Proposal 1.C**: On Rel.17 unified TCI framework, for any DL RS that does not share the same indicated Rel-17 TCI state(s) as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC, but can be configured as a target DL RS of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool), Rel-15/16 TCI state update signaling/configuration mechanism(s) are reused to update/configure the Rel-17 TCI state.

**Proposal 1.D**: On path-loss measurement for Rel.17 unified TCI framework,

* At least for discussion purposes, “beam alignment” is defined as follows:
  + If the PL-RS has a QCL TypeD source RS, beam alignment is defined as the event that the spatial relation RS in the UL or (if applicable) joint TCI state is the same as the QCL TypeD RS of the PL-RS. Else, the PL-RS is identical to the spatial relation RS in the UL or (if applicable) joint TCI state
* For a UE not supporting “beam misalignment”, the UE may assume the PL-RS has the same QCL-TypeD properties as the RS that provides the spatial Tx filter in the UL or (if applicable) joint TCI

**Proposal 1.E**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, the setting of (P0, alpha, closed loop index) for SRS can also be associated with UL or (if applicable) joint TCI state.

* If not associated, the setting(s) of (P0, alpha, closed loop index) for SRS per BWP is independent of the UL or (if applicable) joint TCI states
* This is only applicable for SRS sets using Rel-17 TCI state to determine their spatial relation.

FFS: Whether more than one parameter sets can be configured, e.g. for different traffics

**Proposal 1.F**: On Rel-17 unified TCI, in addition to (M,N)=(1,1), the following combinations are supported: (M,N)=(2,1), (1,2), and (2,2) for mTRP and some sTRP use cases

* Note: At least in Rel-17, the support of N=2 does not imply the support of STxMP
* FFS: Which sTRP use case(s) and other use case(s), e.g. inter-cell beam management, MP-UE
* FFS: How to support M>1 and/or N>1, e.g., association between a Rel-17 unified TCI state with a TCI state group

Table 2 Additional inputs: issue 1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 1**  **2) Share your inputs on the above FL proposals** |
| Apple | Proposal 1.C: We would like to discuss this after we see what the other DL RS would be after we reach consensus for proposal 1.B.  Proposal 1.E: We are ok with the proposal in principle, but we would like to mention that we should allow 2 UL PC parameter sets instead of only 1 UL PC parameter set to be associated with a TCI for different traffics to be aligned with current URLLC design.  [Mod: FFS added] |
| OPPO | Proposal 1.A: we are ok to confirm the WA in general. But propose to make a few changes.   * First, why the ‘configured’ is removed. If it is removed, does it mean that all the CCs in one band are included in this common TCI state ID indication automatically? * Secondly, we propose to change the bullet on how to determine the RS for QCL to FFS. We are not ok to determine the QCL-TypeD RS as the one on the BWP/CC always if CC/BWP ID is absent because we shall ensure all the CC use same RS for TypeD as much as possible. Furthermore, we also need to determine the PL-RS, PC parameters.   **Proposal 1.A**: On Rel.17 unified TCI framework, confirm the following working assumption as an agreement with the following refinement (highlighted in red):  For common TCI state ID update and activation to provide common QCL information at least for UE-dedicated PDCCH/PDSCH and/or common UL TX spatial filter(s) at least for UE-dedicated PUSCH/PUCCH across a set of [configured] CCs/BWPs at least within a band:   * RRC-configured TCI state pool(s) can be configured in the PDSCH configuration (*PDSCH-Config*) for each BWP/CC as in Rel-15/16   + Note: Such RRC-configured TCI state pool(s) configuration doesn’t imply that separate DL/UL TCI state pool is excluded or supported * RRC-configured TCI state pool(s) can be absent in the PDSCH configuration (*PDSCH-Config*) for each BWP/CC, and replaced with a reference to RRC-configured TCI state pool(s) in a reference BWP/CC   + In the PDSCH configuration (*PDSCH-Config*) of the reference BWP/CC, RRC-configured TCI state pool(s) shall be configured   + For a BWP/CC where the PDSCH configuration contains a reference to the RRC-configured TCI state pool(s) in a reference BWP/CC, the UE applies the RRC-configured TCI state pool(s) in the reference BWP/CC * ~~When the BWP/CC ID (i.e.~~ *~~bwp-Id~~* ~~or~~ *~~cell~~*~~) for QCL-Type A/D source RS in a~~*~~QCL-Info~~*~~of the TCI state is absent, the UE assumes that QCL-Type A/D source RS is in the BWP/CC to which the TCI state applies~~ * FFS: How to determine the RS for QCL-TypeA, TypeD, PL-RS and PC parameters for the BWP/CC where TCI state pool is not configured. * Introduce a UE capability to report maximum number of TCI state pools it can support across BWPs and CCs in a band, and the candidate value at least includes 1 * FFS: Introduce a UE capability to report maximum number of configured TCI states that it can support across BWPs and CCs in a band * FFS: How to define reference BWP/CC   [Mod: Please see the revised version. We stick with the previous wording while bracketing the part you have an issue with]  Proposal 1.D We shall consider the following two cases:   * If spatial relation RS is a DL RS, beam alignment is that the spatial relation RS and PL RS are same or the spatial relation RS and PL RS have same QCL-TypeD source. * If spatial relation RS is an SRS, beam alignment is that the spartial relation RS configured to that SRS and the PLRS are same or have same QCL-TypeD source.   **Proposal 1.D**: On path-loss measurement for Rel.17 unified TCI framework,   * For discussion purpose only, “beam alignment” is defined as follows:   + ~~If the PL-RS has a QCL TypeD source RS, beam misalignment is defined as the event that the spatial relation RS in the UL or (if applicable) joint TCI state is the same as the QCL TypeD RS of the PL-RS. Else, the PL-RS is identical to the the spatial relation RS in the UL or (if applicable) joint TCI state~~   + If spatial relation RS in the UL or joint TCI state is a DL RS, beam alignment is defined as the event that the spatial relation RS and the PL-RS are same or have the same QCL-TypeD source.   + If spatial relation RS in the UL or joint TCI state is a SRS, beam alignment is defined as the event that the spatial relation RS configured on that SRS and the PL-RS are same or have the same QCL-TypeD source. * In RAN1#106-e, discuss further and conclude on the UE behaviour when “beam alignment” does not occur   [Mod: Please check the revised version based on a compact version from Ericsson (not differentiating SRS and DL-RS)]  Proposal 1.E: we do not support. We would like to hear why PC parameters for SRS must be associated with each invidual TCI state.  Proposal 1.F: we suggest to first dicuss and settle down the use case for M > 1/ N>1 before we can agree supporting combinations with M > 1 and/or N > 1.  [Mod: To expedite process we can discuss the two together ☺] |
| MediaTek | Proposal 1.A: We are fine with the revised WA, but slight prefer to keep “configured “in the main bullet. In fact, to our understanding, removing “configured” or not makes no difference, where the set of CCs configured with "common beam indication/activation" will still be put in a list according to the previous agreement and only the CCs in the list can apply the TCI pool sharing configuration in this WA.  Agreement  On Rel-17 unified TCI framework, support common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs:  [Mod: I reverted back to the old version and bracketed the part OPPO has an issue with]  Proposal 1.B:   * For CSI-RS and SRS, we prefer to limit applicability only to AP CSI-RS and AP SRS. * For CSI-RS for BM, we prefer to limit applicability only to the CMR set with repetition ON, and whole resources in the CMR set shall apply the same TCI state. * For SRS for BM, similar to CSI-RS for BM, we prefer that whole resources in the SRS resource set shall apply the same TCI state. For SRS set, no repetition would be configured. * For DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs, we think it is necessary to avoid one CORESET may need to apply two TCI states according to legacy MAC-CE indication and Rel-17 DCI indication if it is associated with both CSS set and USS set.   [Mod: Done]  **Proposal 1.B**: On Rel.17 unified TCI framework:   * The following DL RSs can share the same indicated 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     - FFS: : Discuss if/which restriction is necessary, e.g. only for aperiodic   + Some CSI-RS resources for BM     - FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic, repetition ‘ON’, apply to all resources in a set   + DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs * Some SRS resources or resource sets for BM can share the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC   + - FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic , apply to all resources in a set   [Mod: Done]  Proposal 1.C: Support the proposal  Proposal 1.D: Support the proposal. This proposal well cover two possible cases that the PL-RS is configured with and without QCL TypeD source RS. In the sub-bullet for event definition, these may be a typo that the event is defined for “beam alignment” instead of “beam misalignment”. We’d also like to add one clarification for the “else” case to make it clearly. For the case if spatial relation RS is SRS, we can discuss further (not sure why this case was not identified in the corresponding agreement).  **Proposal 1.D**: On path-loss measurement for Rel.17 unified TCI framework,   * For discussion purpose only, “beam alignment” is defined as follows:   + If the PL-RS has a QCL TypeD source RS, beam alignment is defined as the event that the spatial relation RS in the UL or (if applicable) joint TCI state is the same as the QCL TypeD RS of the PL-RS. Else (i.e., the PL-RS has no QCL TypeD source RS), the PL-RS is identical to the spatial relation RS in the UL or (if applicable) joint TCI state * In RAN1#106-e, discuss further and conclude on the UE behaviour when “beam alignment” does not occur   [Mod: Please check the revised version]  Proposal 1.E: Support the proposal  Proposal 1.F: We prefer to confirm the support of M, N > 1 is only for mTRP use case, not just for discussion purposes. Considering there are only a few meetings in Rel-17, it is not a good idea to introduce other special cases for Rel-17 unified TCI framework.  [Mod: I tend to agree from FL perspective]  Before discussing the beam indication signalling mechanism, we suggest to discuss whether Rel-17 unified TCI framework can support S-DCI, M-DCI, or both, since different signalling mechanisms may be needed for these use cases.  [Mod: Now removed] |
| Qualcomm | For Proposal 1.A, fine with the FL’s proposal. Btw, can FL remind of the concern for “configured”?  [Mod: Reverted back to the old version with additional brackets per OPPO’s input]  For Proposal 1.B, fine with the FL’s proposal. Prefer no restriction  For Proposal 1.C, support the FL’s proposal  For Proposal 1.D, suggest to remove “For discussion purpose only”. Without such definition in spec, gNB and UE may not be aligned on the capability  [Mod: done]  For Proposal 1.E, fine with the FL’s proposal. It should work to our understanding.  For Proposal 1.F, do not support. We should focus on single TRP use cases, including beam diversity and L1/L2 mobility. Unified TCI cannot be extended to mTRP in R17 anyway.  [Mod: Some work on mTRP can be done in Rel-17 after sTRP is mature enough, just as now] |
| Lenovo/MotM | Proposal 1.A: We are OK with confirming the WA, but prefer to keep the world “configured” in the main bullet.  Proposal 1.B: We do not support to have DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs share the same indicated R17 TCI state as as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC. This will limit the flexibility of the gNB. The gNB shall be able to use different DL beams for UE specific PDSCH/PDCCH and non-UE specific PDCCH/PDSCH. For example, DCI format 2\_2 carries TPC command for many UEs. If it shares the same TCI to PDCCH to a specific UE, its multiplexing capability will be greatly compromised.  Proposal 1.C: We do not support this proposal. Rel. 17 TCI update mechanism shall be used to these DL RS.  Proposal 1.D: We think requiring the PL-RS and the DL-RS used as TCI state for UL to be same for beam alignment is too restrictive. It shall be relaxed so the beam misalignment event is defined when the PL-RS and DL-RS used as TCI state for UL have different QCL-TypeD SSBs.  Proposal 1.E: Support this proposal.  Proposal 1.F: Do not support. We are OK to focus the discussion on mTRP, but both mDCI- and sDCI-based shall be supported.  [Mod: Please see latest version] |
| InterDigital | Proposal 1.B: Sharing the same Rel-17 TCI state with CSI-RS resources for BM or SRS resources for BM is not necessary and rather restricting the BM feature, as those are used for BM where gNB can have some flexibility to control the beams directly. Further optimizations depending on specific conditions, e.g., aperiodic, repetition ‘ON’, etc. are also not necessary, since the current spec up to Rel-16 has already sufficient flexibility in beam indications on those resources for BM.  Proposal 1.C: Support FL’s proposal.  Proposal 1.E: Support FL’s proposal.  Proposal 1.F: Do not support. Single TRP with multi-beam, MPUE(e.g., Rel-16 PUCCH resource groups), and Multi TRP are all important use cases and no need to differentiate in terms of spec supports with fragmented operation per particular case. To make the standard sufficiently general for various use cases, TCI state grouping and a group-ID for each group seems sufficient for UE-transparently covering multiple use cases, even for different channels/signals, for the sake of unified framework for TCI signaling.  [Mod: Given companies’ views and uncertainty on MPUE, the best I can do is to add FFS for other use cases] |
| NTT Docomo | Proposal 1.A: We support to confirm the WA.  Re OPPO’s comment, we don’t agree to make FFS on how to determine the RS for QCL-TypeA, TypeD. This is a key part of the working assumption. We don’t understand the comment of “…*because we shall ensure all the CC use same RS for TypeD as much as possible.*”. It is up to gNB configuration whether to use CC-specific QCL type D RS (e.g. TRS) or CC-common QCL type D RS (e.g. CSI-RS with repetition), from Rel.15 NR spec. Also, how to determine PL-RS, PL parameters is separate issues.  [Mod: I tend to agree. We can discuss further]  Proposal 1.B~1.E: OK.  Proposal 1.F: Not support. We should focus on M=N=1 case first in Rel.17, and after that, we can enhance it to M, N >1. If we discuss on mTRP, both mDCI- and sDCI-based should be supported.  [Mod: Understood.] |
| Sony | **Proposal 1.A:** we are supportive to confirm the WA. And we slightly prefer to keep ‘configured’ CCs/BWPs which seems aligned with previous agreement in Rel.17 and the spirit of Rel.16 Multi-CC common beam updating. Without it, RAN1 may need to argue on how to determine such a set of CCs/BWPs.  **Proposal 1.B:** support the FL proposal.  **Proposal 1.F:** thanks for the proposal, we would like to ask whether the beam indication signaling (2nd bullet) applies to mTRP use case only? If yes, we then suggest to make that clear, otherwise proponents of other use cases (e.g. sTRP or CORESET diversity) may interpret the 2nd bullet applies to all possible use cases.  And it seems too early to down-select mDCI-based or sDCI-based signaling. Looking back the DCI design for Rel.16 mTRP PDSCH, there is a chance to support dynamic signaling mechanisms.  [Mod: Yes this is for mTRP only. Latest version may address your points, please check] |
| FGI/APT | Proposal 1.A: We are willing to confirm the WA. We are open to remove [configured] or keep it, which seems no big difference to us.  Proposal 1.B: Support. We agree with MTK’s assessment that “DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs” should be supported, since beam indication of PDCCH is per CORESET, not search space.  Proposal 1.D: Support in general. But we may need to further clarify that in “else” case, what’s the corresponding definition when the spatial RS in UL/joint TCI is a SRS.  Proposal 1.E: Support  Proposal 1.F: We are OK with the first sub-bullet. Regarding the second, some clarifications may be needed. We think Alt 1 and Alt 2 are not exclusive, since both are valid use case in mTRP scenario. Hence, we are not sure why down-selection is needed here.  [Mod: I agree, please see latest version] |
| Ericsson | **Proposal 1.A:** We are not OK with the addition of “at least within a band”: specification of this feature will be band-agnostic.  [Mod: Reverting to original wording + one more bracketed text per OPPO’s input]  **Proposal 1.B**: Support  **Proposal 1.C:** Support  **Proposal 1.D:** This seems to be unnecessarily complicated, and also incomplete. We could also have that the QCL source of the RS that provides the spatial UL Tx filter is equal to the PL RS. And we could have longer QCL chains. A complete proposal could be  **Proposal 1.D**: On path-loss measurement for Rel.17 unified TCI framework,   * For discussion purpose only, “beam alignment” is defined as follows:   + Beam alignment occurs if the QCL Type D properties of the PL-RS and the RS that provides the spatial Tx filter in the UL or (if applicable) joint TCI state are the same. * In RAN1#106-e, discuss further and conclude on the UE behaviour when “beam alignment” does not occur   [Mod: I prefer this version better]  **Proposal 1.E:** Support  **Proposal 1.F:** Do not support. If we support M or N >1, the procedures should be general enough to provide TCI states not only for mTRP mDCI. Also, the proposal is imprecise: the TCI states are not updated.  [Mod: We now focus on the main bullet and use case] |
| Fraunhofer IIS/HHI | **Proposal 1.A:** We believe it’s OK to keep ‘configured’ in the main bullet.  **Proposal 1.B:** In both the case of CSI-RS for BM and SRS for BM, we believe that the unified TCI cannot be applied to all resources or resource sets and they have to be applied in a restricted manner so that the other resources or resource sets can be used for beam sweeping. Moreover, there is not parameter ‘repetition’ for SRS with ‘ON’/‘OFF’ value. Therefore, the FFS for CSI-RS and SRS could be modified as follows:  For CSI-RS: ‘FFS: Discuss which restriction is necessary, e.g., only for aperiodic, repetition=‘ON’, etc.’  For SRS: ‘FFS: Discuss which restriction is necessary, e.g., only for aperiodic, etc.’  [Mod: Current version has if/which, whether we can make it ‘which’ only can be durther discussed]  **Proposal 1.C:** Support  **Proposal 1.D:** Prefer OPPO’s revision to deal with two different cases of spatial relations for UL with the following change for the second sub-bullet  **Proposal 1.D:** On path-loss measurement for Rel.17 unified TCI framework,   * For discussion purpose only, “beam alignment” is defined as follows:   + ~~If the PL-RS has a QCL TypeD source RS, beam misalignment is defined as the event that the spatial relation RS in the UL or (if applicable) joint TCI state is the same as the QCL TypeD RS of the PL-RS. Else, the PL-RS is identical to the the spatial relation RS in the UL or (if applicable) joint TCI state~~   + If spatial relation RS in the UL or joint TCI state is a DL RS, beam alignment is defined as the event that the spatial relation RS and the PL-RS are same or have the same QCL-TypeD source.   + If spatial relation RS in the UL or joint TCI state is a SRS, beam alignment is defined as the event that the spatial relation RS configured ~~on~~ for the ~~that~~ SRS ~~and~~ is the PL-RS or the PL RS has the ~~have the~~ same QCL-TypeD source as the spatial relation source of the SRS.   In RAN1#106-e, discuss further and conclude on the UE behaviour when “beam alignment” does not occur  [Mod: Please check revised version based on Ericsson’s input – differentiating SRS from DLRS may not be necessary]  **Proposal 1.F:** We have some doubts regarding the values for M and N. Alt. 1 and 2 suggest that M and/or N TCI states can be updated in an instance which, we believe, may mean that there may be update of uplink-only or downlink-only TCI states. In such cases, either M or N is equal to zero, which is not reflected in the main bullet. We would prefer that such updates are also possible for MTRP.  [Mod: There is no DL-only traffic, neither is there UL-only traffic. Only updating DL-only or UL-only TCI doesn’t imply N=0 or M=0, respectively.] |
| Samsung | **Proposal 1.A:** We are fine to confirm the WA with the suggested changes. Also fine to confirm the original WA and then further discuss [configured] and any other changes that may be needed.  **Proposal 1.B:** Support  **Proposal 1.C:** Support  **Proposal 1.D:** “Beam alignment” definition, is when the PL-RS and spatial relation RS have the same QCL Type-D properties. We are fine with the proposed update from Ericsson.  [Mod: Done]  **Proposal 1.E**: Support  **Proposal 1.F:** Support first bullet. For the second bullet, although we see the need for supporting both mDCI and sDCI for mTRP, we prefer to focus on mDCI-like solution (Alt1) in Rel-17 and defer sDCI-like solution (Alt2) for Rel-18, where one sDCI includes TCI states for 2 TRPs. This is because it has been agreed that repurposing of unused codepoints of DCI format 1\_1/1\_2 cannot done in Rel-17. Unless the maximum number of activated TCI states can be increased beyond 8, Alt2 would result in unnecessarily more frequent TCI state activation when used for mobile (non-stationary, non-FWA) scenarios – which results in increase in latency and overhead.  sDCI with TCI state code points signaled for one TRP at a time, can be considered in Rel-17.  [Mod: Point taken and agreed. This can be discussed next. It seems we are still stuck at the values and use cases based on companies’ inputs] |
| Intel | **Proposal 1.A:** We are ok confirm WA. For the 2nd last FFS on UE capability for the maximum number of configured TCI states, we don’t think it’s needed at this point. Can be further discussed during UE capability discussion. For the definition of the reference CC, it may be the CC in which the RRC state pool is configured when it is not configured per CC.  [Mod: We can keep the FFS for now ☺]  **Proposal 1.B:** We are not sure about the DM-RS for non-UE dedicated reception. Since we also have inter-cell beam management without serving cell change, our understanding is that common control and non-UE dedicated signaling may be received from original serving TRP while the UE dedicated reception may be switched to non-serving TRP. In this case, mandating the DM-RS to share the same TCI may not work.  **Proposal 1.C:** For this case, we prefer a Rel-17 mechanism so as not to specify fragmented mechanism for Rel-15/16 and Rel-17 which would co-exist. Furthermore, the discussion on TCI state pool may have some impact.  [Mod: This is perhaps better discussed in later rounds after 1.B is settled]  **Proposal 1.D:** The definition should be for beam “alignment”? Also, we should clarify that this agreement has no specification impact. Further discussion on specification impact is based on the last bullet.  [Mod: Sorry it was a typo. Please check latest version]  **Proposal 1.E:** OK  **Proposal 1.F:** We are not OK with this proposal. We can only support the first sub-bullet and Alt.1 of the 2nd sub-bullet. Given the work of Rel-17, we suggest to only focus on M,N = (1,1) for sTRP. For mTRP with multi-DCI, it is not clear why M,N>1 is needed. Each DCI can use a separate TCI codepoint with M=N=1 to update the TCI for the respective CORESETPoolIndex. The only use case of M,N>1 for mDCI mTRP is the case when single DCI codepoint is used by both CORESETPoolIndexes. This use case is not important. Additionally, for sDCI mTRP, since repetition schemes are still under discussion, TCI update should be discussion once such discussion is concluded. Additionally, for the sDCI case, there is an ambiguity in which UL TCI is selected for transmission. These discussions should be relegated to the next release. We believe it is better to completely specify sTRP with M,N=(1,1) in this release. |
| LG | Proposal 1.B: support in general. We don’t think that all CSI-RS resources for CSI would be UE-specifically beamformed. So ‘CSI-RS resources for CSI’ should be modified to ‘Some CSI-RS resources for CSI’. Overall, the easiest way to handle this issue is to make target channels to be configurable regardless of its usage (CSI, BM, etc).  [Mod: Done]  Proposal 1.D: It should be further considered for ‘beam misalignment’ when the spatial RS is SRS for UL TCI or a SP/AP DL RS for UL/joint TCI, which cannot be used as PL RS.  Proposal 1.F: Main bullet is ok. Regarding sub-bullets, we think sTRP and MPUE use cases are also important as other companies commented. We prefer to introduce a usage-agnostic method which is applicable to multiple usages. In this regard, we propose following modification to be more general:  **Proposal 1.F**: On Rel-17 unified TCI, in addition to (M,N)=(1,1), the following combinations are supported: (M,N)=(2,1), (1,2), and (2,2)   * ~~For discussion purposes, focus on the mTRP use case~~ * For beam indication signalling mechanism, down-select from the following alternatives:   + Alt1. ~~mDCI-based:~~ One beam indication instance updates only one of the M and/or N TCI states   + Alt2. ~~sDCI-based:~~ One beam indication instance can update all the M and/or N TCI states~~, where one codepoint can be associated with M and/or N TCI states~~   [Mod: Please check latest version focusing on the values and use cases] |
| Xiaomi | Proposal 1.A: we are fine with this proposal and prefer to keep “configured”  Proposal 1.B: as for the DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs, since CSS set and USS set may associated with a same CORESET, and the TCI state is configured per CORESET, we think it is possible that non-UE-dedicated reception on PDSCH and all/subset of CORESETs share the same TCI state as UE-dedicated PDSCH/CORESET or UE-dedicated PUSCH/PUCCH.  Proposal 1.C: we are fine with this proposal.  Proposal 1.F: we are fine with this proposal and we prefer to consider Alt 1 first. While for Alt 2, we can accept it if joint TCI state configured for both two TRPs. Else, we think 3bit TCI filed need to be increased. |
| MediaTek | **Proposal 1.D**: We are also fine with Ericsson’s suggestion with more general description, and it would be better to directly define the corresponding UE behavior if UE doesn't support “beam misalignment”. For example:  **Proposal 1.D**: On path-loss measurement for Rel.17 unified TCI framework,   * For a UE not support “beam misalignment”, the UE may assume the PL-RS has the same QCL-TypeD properties as the RS that provides the spatial Tx filter in the UL or (if applicable) joint TCI state.   [Mod: Added] |
| ZTE | **Proposal 1.A:** Not support. We still fail to understand why the following bullet can NOT be confirmed together.   * When the BWP/CC ID (i.e. *bwp-Id* or *cell*) for QCL-Type A/D source RS in a *QCL-Info* of the TCI state is absent, the UE assumes that QCL-Type A/D source RS is in the BWP/CC to which the TCI state applies   Regarding OPPO’s comments, we share the same views with DOCOMO that how to determine PL-RS, PL parameters (that have not been discussed at all) is a separate issue. In our views, we are open to other reasonable enhancement for cross CC, but we need to move forward them one by one. It is unrealistic to combining all opening issues together. In our views, if no detailed comments on this bullet, we fail to identify why we can not confirm this bullet together that is essential for enabling the cross-CC QCL Type A/D indication by TCI state, and then we can further discuss ‘PL-RS and PL parameter’ later.  [Mod: I see your point. I will remove the brackets and we can continue discussion on the additional points raised by OPPO]  In general, we can fine to confirm the original WA directly.  **Proposal 1.B:** We can support this proposal except that we should clearly mention that this proposal applies to aperiodic CSI-RS only rather than all types of time-domain behaviors.   * + - In order to save RS overhead, the periodic RS is cell-specific RS from gNB perspective, and we have to experience very huge RS overhead once we allow to configure UE-specific periodic RS for facilitating the dynamic/UE-specific TCI update, unless that the TCI state can further adjust a time-domain offset of P/SP- CSI-RS in order to match cell-specific CSI-RS/TCI time pattern in gNB side.   [Mod: Let’s leave that for next level discussion for progress]  **Proposal 1.C:** Support  **Proposal 1.D:** Not support, and we prefer the previous FL proposal. We sympathize with Ericsson’s comments, but if my understanding is correct, the consensus herein is just to support the identical RS for PL estimate and QCL-Type D determination, rather than a long QCL chain.  [Mod: As far as I understand it, Ericsson’s version is a more compact version of my previous version but they are essentially the same. Please check the latest version per Qualcomm’s input ]  **Proposal 1.E**: Support. Unified TCI state is supposed to be applied for SRS with the same Tx beam as PUSCH, and it is straightforward that such SRS should share the same closed loop value with the currently active closed loop of PUSCH. That is, the closed loop procedure for SRS should be tied with the currently active PUSCH closed loop, and consequently, considering dynamic switching for PUSCH closed loop index, the association is very necessary.    **Proposal 1.F**: Support. We prefer to treat mDCI-mTRP and sDCI-mTRP equally. |
| Qualcomm | **For Proposal 1.A, suggest to remove bracket on the 3rd bullet. QCL RS is already discussed for the whole last meeting. Other issues should be discussed separately. Please do not mix up issues to delay the progress. We are also fine to confirm the original WA, unless there is any fundamental error.**  [Mod: Please check latest version. Done]  **For Proposal 1.B, suggest to remove the 3 “Some” or change them to “At least some”. Because if the restriction in FFS is not agreed then NW can let all resources to share an indicated TCI, instead of only some.**  [Mod: Done]  **For Proposal 1.C, support the latest version.**  **For Proposal 1.D, suggest the following wording in red.**   * […]   + Beam alignment occurs if the RS that provides the QCL Type D properties of the PL-RS and the RS that provides the spatial Tx filter in the UL or (if applicable) joint TCI state are the same. * […]   [Mod: Done]  **For Proposal 1.E, fine with the latest version.**  **For Proposal 1.F, we are not ok to leave sTRP to FFS. The reliability is even worse than R15 and is not acceptable. Also, how can M=N=1 handle the L1/L2 mobility case where at least 1 TCI is needed for broadcast on serving PCI and at least another TCI is needed for unicast on non-serving PCI? UE has to support M=N=2 for sTRP in that case.**  [Mod: The current version is based on companies’ views. But I see your point. I will add ‘inter-cell beam management’ and see what other companies say]  **Proposal 1.F**: On Rel-17 unified TCI, in addition to (M,N)=(1,1), the following combinations are supported: (M,N)=(2,1), (1,2), and (2,2) for both sTRP and mTRP use cases |
| Convida Wireless | Proposal 1.A: OK to confirm WA.  Proposal 1.B: Support.  Proposal 1.C: Support.  Proposal 1.D: Support Ericsson’s version.  Proposal 1.E: OK  Proposal 1.F: Not support. While supportive of the multi-TRP use case, we prefer to complete M=N=1 in Rel-17 and discuss M>1, N>1 in Rel-18. There are still many remaining issues for the unified TCI framework for M=N=1, not to mention the amount of remaining issues in the MB sub-agenda item. Another benefit of waiting with M>1, N>1 is that it allows Rel-17 multi-TRP PDCCH/PUCCH/PUSCH enhancements to complete.  [Mod: Sympathizing your valid point, but the proposal is made based on majority view ☺] |
| Mod V26 | Revised |
| MediaTek | Proposal 1.D: Regarding the additional wording “the RS that provides”, it may lead to a missing case if PL-RS is not provided with QCL-TypeD source RS, e.g., SSB. We think the original wording suggested by Ericsson is fine, which just reuses similar language as in TS38.213 specifying the beam alignment between different CORESETs.  If a UE  - …  the UE monitors PDCCHs only in a CORESET, and in any other CORESET from the multiple CORESETs having same QCL-TypeD properties as the CORESET, on the active DL BWP of a cell from the one or more cells  - …  [Mod: I tend to agree]  Proposal 1.F: Regarding the use case for inter-cell beam management, we think even M = N = 1 still can support the scenario mentioned by Qualcomm. Similar to intra-cell case, Rel-15/16 signaling mechanism can be used to provide TCI for broadcasting channel on serving PCI, and Rel-17 joint/separate TCI (M=N=1) is used to provided TCI for unicasting channel on non-serving PCI. To our understanding, if M and N are increased, it means RAN1 is going to extend Rel-17 MAC-CE/DCI-based TCI update to support M, N > 1.  [Mod: Now moved to an example for FFS] |
| Huawei, HiSilicon | Proposal 1 A: Ok to confirm, prefer to keep “configured”.  Proposal 1.B: Do not support. With R16, aperiodic CSI-RS for BM/CSI follows QCL assumption of PDCCH if the scheduling offset is smaller than a threshold, and its QCL assumption is indicated by DCI if the scheduling offset is larger than a threshold. We do not see clear gains from what is being proposed here. SRS for BM can be used for UL beam indication and letting it follow PUSCH/PUCCH will create unclear spatial relation loops.  Proposal 1.F: Suggest adding a note saying “The support of N=2 does not imply the support of STxMP”.  [Mod: Good point. I also added “at least for Rel-17”] |
| InterDigital | For Proposal 1.F, we think only listing some use cases for M>1 or N>1 may not result in meaningful progress, and rather it is risky to restrict to only a few use cases at this moment, since the subsequent detail should be anyway general enough to support multiple important use cases for future proofness as well.  As multiple companies already mentioned so far in that spirit, we also think supporting “usage-agnostic” signaling (analogous to Rel-16 PUCCH resource grouping) seems efficient and sufficient for necessary enhancements in regards to M>1 or N>1, which only requires minimal spec impacts on having TCI state grouping with group-ID. In that sense, an updated Proposal 1.F can be suggested as follows:  **Proposal 1.F**: On Rel-17 unified TCI, in addition to (M,N)=(1,1), the following combinations are supported: (M,N)=(2,1), (1,2), and (2,2) at least for mTRP, sTRP with multi-beam, and inter-cell beam management use cases   * Support usage-agnostic signaling by TCI state grouping (analogous to Rel-16 PUCCH resource grouping), where a Rel-17 TCI can be associated within a TCI state group, when M>1or N>1.   FFS: Other use case(s)  [Mod: Added FFS for this] |
| CATT | For Proposal 1.A, support.  For Proposal 1.B, support and restriction is needed.  For Proposal 1.C, not support. We prefer a unified TCI configuration scheme in Rel-17. We are fine to discuss this issue after proposal 1B has been stable.  For Proposal 1.D, not support. The mentioned ‘else’ cases are not quite clear to us. We support the updated version from Ericsson.  [Mod: Current version is based on Ericsson’s wording]  For Proposal 1.E, support.  For Proposal 1.F, not support. sTRP should also be included in this scenario. In addition, for mTRP, both mDCI and sDCI should both be supported. |
| NEC | Proposal 1B, we think explicit configured BFD RS should also share the same indicated Rel-17 TCI state, otherwise beam for beam failure detection may be mismatched with common beam for PDCCH.  [Mod: This was not included in the previous agreement in RAN1#105-e. I’d appreciate other companies sharing their views.] |
| vivo | Proposal 1.A: we are fine to confirm the working assumption with the following update.  **Proposal 1.A**: On Rel.17 unified TCI framework, confirm the following working assumption as an agreement and continue discussion on the bracketed parts (to be concluded in RAN1#106-e):  For common TCI state ID update and activation to provide common QCL information at least for UE-dedicated PDCCH/PDSCH and/or common UL TX spatial filter(s) at least for UE-dedicated PUSCH/PUCCH across a set of [configured] CCs/BWPs:   * RRC-configured TCI state pool(s) can be configured in the PDSCH configuration (*PDSCH-Config*) for each BWP/CC as in Rel-15/16   + Note: Such RRC-configured TCI state pool(s) configuration doesn’t imply that separate DL/UL TCI state pool is excluded or supported * RRC-configured TCI state pool(s) can be absent in the PDSCH configuration (*PDSCH-Config*) for each BWP/CC, and replaced with a reference to RRC-configured TCI state pool(s) in a reference BWP/CC   + In the PDSCH configuration (*PDSCH-Config*) of the reference BWP/CC, RRC-configured TCI state pool(s) shall be configured   + For a BWP/CC where the PDSCH configuration contains a reference to the RRC-configured TCI state pool(s) in a reference BWP/CC, the UE applies the RRC-configured TCI state pool(s) in the reference BWP/CC * When the BWP/CC ID (i.e. *bwp-Id* or *cell*) for QCL-Type A/D source RS in a *QCL-Info* of the TCI state is absent, the UE assumes that QCL-Type A/D source RS is in the BWP/CC to which the TCI state applies * Introduce a UE capability to report maximum number of TCI state pools it can support across BWPs and CCs in a band, and the candidate value at least includes 1 * Only 1 reference BWP/CC is expected within the set of [configured] CCs/BWPs * FFS: Introduce a UE capability to report maximum number of configured TCI states that it can support across BWPs and CCs in a band * FFS: How to define reference BWP/CC   [Mod: This is a part of the last FFS point that needs to be discussed further in this meeting which should not prevent the group from confirming the WA.]  Proposal 1.B: Do not support the proposal. We think these DL RS cannot share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs, and SRS resource for BM cannot share the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources.   * For CSI-RS and SRS for beam management, the joint/separate TCI state cannot be applied since they are used for beam tracking and refinement through beam sweeping. * For CSI-RS for CSI acquisition, the UE can maintain CSI measurement for different TCI states flexibly, not limited to measure CSI based on indicated joint TCI state or separate DL TCI state. * For DMRS(s) associated with non-UE-specific CORESET, they are related to L1/L2 mobility. Behavior should be clarified for L1/L2 mobility first before we touch this part.   Proposal 1.C: we don’t support this proposal. If an RS is configured as a target DL RS of Rel-17 DL TCI, the unified Rel-17 TCI state update signaling/configuration mechanism(s) are used, e.g. with Rel-17 MAC-CE-based beam indication.  Proposal 1. D: Prefer to limit this to discussion purpose or FFS how to capture this, in UE capability or directly in RAN1 spec.  [Mod: “For discussion purposes” was added back]  Proposal 1.E: the UL PC setting framework similar to PUCCH and PUSCH can be used for SRS. The PC setting for SRS is associated with the R17 TCI state only when the same R17 TCI state of PUCCH/PUSCH is applied for SRS, i.e. same R17 TCI state is used for PUCCH, PUSCH and SRS, and the different PC settings are associated with this TCI state respectively. We think the PC setting for SRS is set level, where the PC setting is applied to all SRS resources in SRS resource set.  **Proposal 1.E**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, the setting of (P0, alpha, closed loop index) for SRS can also be associated with UL or (if applicable) joint TCI state.   * If not associated, the setting(s) of (P0, alpha, closed loop index) for SRS per BWP is independent of the UL or (if applicable) joint TCI states * This is only applicable for SRS sets using Rel-17 TCI state to determine its spatial relation.   FFS: Whether more than one parameter sets can be configured, e.g. for different traffics  [Mod: Done] |
| Futurewei | Proposal 1.A: We are ok to confirm the WA.  Proposal 1.B: Do not support. The listed DL RSs serve different purpose (e.g., beam sweeping, etc.) from the UE-dedicated PDSCH and UE-dedicated CORESETs, therefore they should not share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC. Similarly, some SRS resources or resource sets for BM should not share the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC.  Proposal 1.C: Do not support. Our view is that a mixture of Rel-15/16 TCI state update signaling/configuration mechanism(s) and Rel-17 TCI state update signaling/configuration mechanism(s) should be avoided to reduce UE complexity.  Proposal 1.D: It seems the current wording will treat the following case as beam misalignment: the RS that provides the spatial Tx filter in the UL or (if applicable) joint TCI state is the PL-RS, which is different from the RS that provides the QCL Type D properties of the PL-RS. But this case should be treated as beam alignment.  [Mod: please check current version. Your comment seems to be based on an older version]  Proposal 1.E: Support.  Proposal 1.F: We share the same view as Qualcomm that sTRP case should also be listed as the use case for M>1 and/or N>1 such that R17 is at least as reliable as R15. |
| Spreadtrum | Proposal 1.A: Support to confirm the WA.  Proposal 1.B: For CSI-RS for BM and SRS for BM that can share the common beam, since there are different understandings on the applicable configuration, we suggest to discuss and decide which configuration/restriction is feasible, rather than firstly agree on ‘some’.  Proposal 1.C: Support the proposal. For Alt2, other than the impact of spec workload, we wonder how many DCIs will be needed to indicate TCI states for each of the RSs/channels that cannot share the common beam.  Proposal 1.E: Support the proposal.  Proposal 1.F: In our view, S-DCI and M-DCI should be supported together. Considering the workload, we prefer to discuss it in further release. |
| CMCC | Proposal 1.F: We think both M-DCI and S-DCI should be considered, but for S-DCI, beam indication would be more complex. We can discuss S-DCI case or all M, N >1 case in further release.  [Mod: I sympathize with this view. This will be discussed later once we agree on the support of M/N=2 and potential use case(s)] |
| Mod V37 | Revised |
| Ericsson | Proposal 1.A: Support  Proposal 1.B: Support. For CSI-RS, we should as a minimum support what Rel-16 supports: that all aperiodic CSI-RS use the default beam if the scheduling offset if too small. Using only configured QCL sources is problematic, due to the UE feature 2-35-5: different QCL sources means different triggering states. With 64 SSBs, the available triggering states quickly increases. However, always scheduling with a small threshold is not good either: this reduces the possibilities for UE power savings. Having the desired behavior irrespective of the scheduling threshold seems like a good idea.  Proposal 1.C: Support.  Proposal 1.D: Support  Proposal 1.E: Support  Proposal 1.F: Do not support. After reading TDocs, it is getting clear that there are still many open issues for M=N=1, so we propose to postpone M,N>1 to Rel-18. Any solution that we do standardize should not be thrown out in Rel-18. |
| Mod V39 | No change from V37 |
| MediaTek | Proposal 1.F: Regarding the newly added FFS, we prefer to revised it as:   * FFS: How to support M>1 and/or N>1, e.g., association between a Rel-17 unified TCI state with a TCI state group   [Mod: Done] |
| ZTE2 | Proposal 1.A: Support  Proposal 1.B: As we mentioned before, we can only accept the enhancement for aperiodic CSI-RS. If ‘Some CSI-RS resources for CSI/BM’ does not implies that all time-domain types of CSI-RS should be supported by default, we can live with the proposal.  [Mod: Added clarification]  Proposal 1.C: Support  Proposal 1.D: As we mentioned before, the beam alignment refers to that the associated PL-RS should be the same as periodic DL source RS in the UL or (if applicable) joint TCI state to provide spatial relation indication. We can support the original version, but can NOT this one.  [Mod: It seems a few companies have some problem with the wording proposed by Ericsson but the older version seems ok. Back to the older version.]  Proposal 1.E: Support. In technical, the closed loop procedure for SRS should be tied with the currently active PUSCH closed loop.  Proposal 1.F: Support in principle. It is a little bit confusing: association between a Rel-17 unified TCI state with a TCI state group. Does it mean to map between a TCI state group and a TRP (for mTRP case) / cell (for inter-cell case)? If so, some clarification seems better.  [Mod: The proponent can perhaps clarify. But anyway this is FFS] |
| Nokia/NSB | Proposal 1.A: Support confirming the WA.  We propose to split 1.B to DL and UL:  [Mod: Done]  **Proposal 1.B-1**: On Rel.17 unified TCI framework:   * The following DL RSs can share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC   + Some CSI-RS resources for CSI     - FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic   + Some CSI-RS resources for BM     - FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic, repetition ‘ON’, apply to all resources in a set   + DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs   **Proposal 1.B-2**: On Rel.17 unified TCI framework:   * Some SRS resources or resource sets for BM can share the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC   + FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic, apply to all resources in a set   We would support 1.B-1. We would not support 1.B-2 – our intention was that SRS for BM can be provided “Rel17 UL TCI state”, but not “Indicated Rel17 TCI state”.  Proposals 1.C-1.F are fine. |
| LG | Proposal 1.D: For the second bullet, is it correct understanding for a UE not supporting ‘beam misalignment’ that the case when the spatial RS is SRS for UL TCI or SP/AP DL RS for UL/joint TCI is to be covered or needed to discuss further?  [Mod: If the need for further discussion on this issue is clear, sure]  Proposal 1.F: We share a similar view with Futurewei, CATT and Qualcomm that sTRP and MPUE can be included as use cases for M, N >1  [Mod: Added] |
| Lenovo/MotM | Proposal 1.F: We share the same view as Qualcomm and Futurewei. The M>1, N>1 shall be designed to support sTRP and MPUE.  [Mod: Added] |
| AT&T | Proposal 1.A-1.D: support  Proposal 1.F: do not support. There are valid use cases for s-TRP and m-TRP for M/N>1. Even if s-TRP is excluded as a use case, both m-DCI and s-DCI should be considered for mTRP use case for M/N>1.  [Mod: Added “some sTRP” and FFS on which ones] |
| Qualcomm | For Proposal 1.A-1.C, support  For Proposal 1.D, prefer to add “the RS that provides”. To our understanding, “the QCL TypeD properties” refer to Rx beam. Not sure what is the meaning of “Rx beam and the RS that … are the same”.  [Mod: Please check the revised version – back to the old version based on Qualcomm;s Tdoc]  For Proposal 1.E, fine.  For Proposal 1.F, not support. sTRP is equally important as mTRP. To our understanding, R17 is hard to extend unified TCI to all mTRP features including those under discussions. It makes more sense to complete sTRP with unified TCI in R17. The remaining time should be sufficient for that to our understanding. We are fine to continue mTRP in R18.  [Mod: Added] |
| Mod V48 | Revised |

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

Table 3 Summary: issue 2

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1 | Confirm WA on beam indication along with necessary refinements  **Working Assumption**  On Rel.17 beam indication enhancements for L1/L2-centric inter-cell mobility, support the following:   * Rel-17 MAC-CE-based and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation)   + [2.1.1] FFS (to be decided in RAN1#106-e): Whether this also applies to PDSCH/PUSCH associated with UE-dedicated CORESETs only or additional target channels (e.g. UE-dedicated PDCCH/PUCCH)   + [2.1.2] FFS: Whether the above is supported only for joint TCI, or both joint TCI and separate DL/UL TCI (including that, if separate DL/UL TCI is supported, the DL TCI and UL TCI associated with a same cell)   + [2.1.3] FFS: Whether to support activation of TCI states for more than one cells simultaneously   + [2.1.4] FFS: Whether down-selection between MAC-CE only based and MAC-CE+DCI-based beam indication scheme is necessary * The DL QCL and UL spatial relation rules already agreed for intra-cell scenario * [2.1.5] FFS: The use of SSB associated with a physical cell ID different from that of the serving cell as an indirect QCL reference for UE-dedicated PDSCH   + FFS (to be decided in RAN1#106-e): Whether this also applies to UE-dedicated PDCCH   + Note: When RS X is an indirect QCL reference of a target channel, there exists at least one other source signal on the QCL chain between RS X and 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   Note: RAN#92 has concluded (captured in the revised WID) that inter-cell beam management will be used instead of L12XCM since no change in serving cell is assumed  **Note: also discussed offline [1] section 3** | 2.1.1: TCI applied to:   * Data and control (delete FFS): vivo, Samsung, Ericsson, Apple, NTT Docomo, MTK, Sony, Xiaomi, CATT (PDCCH/PUCCH optional), Intel, ZTE * Data only:   2.1.2:   * Joint: Samsung, Ericsson, NTT Docomo, Intel, Xiaomi, ZTE, CATT * Separate: MTK (DL NSC, UL SC), Ericsson, NTT Docomo, Samsung (DL and UL associated with the same cell), Intel, Xiaomi,CATT   2.1.3:   * One cell: CATT, OPPO, MTK, Apple, Xiaomi, ZTE * More than one cell: Samsung, NTT Docomo   2.1.4:   * MAC-CE only: Huawei/HiSi * MAC CE+DCI only: * No Downselection (delete FFS): Sony, Samsung, CATT, Fujitsu, Ericsson, NTT Docomo, ZTE, MTK, Qualcomm, Intel, Xiaomi   2.1.5:   * SSB Indirect QCL only: Huawei, Sony, OPPO, CMCC, Ericsson, Apple, Intel, LG, CATT * SSB Direct+Indirect QCL: Samsung, NTT Docomo, MTK, ZTE |
| 2.2 | Support the following RS types as 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/MotM, Fujitsu, Sony, LG, ZTE, Spreadtrum,CATT * **No**: Nokia/NSB, Samsung, Xiaomi, OPPO, MTK, Intel, IDC, Ericsson, Intel   CSI-RS for BM associated with NSC:   * **Yes**: Nokia/NSB, Ericsson, AT&T, Spreadtrum, Intel, IDC * **No**: Samsung, OPPO, Xiaomi, MTK   CSI-RS for tracking (TRS) associated with NSC:   * **Yes**: Lenovo/MotM * **No**: Samung, OPPO, Xiaomi, Spreadtrum, MTK, IDC, Ericsson, Intel |
| 2.3 | Maximum value of K (beams associated at least with non-serving cell(s) reported in a single CSI reporting instance), i.e. KMAX beyond 4 (already agreed)  Note: UE capability of supporting < KMAX is neither ruled out nor within the scope of 2.2 | **8**: Ericsson, Nokia/NSB, AT&T, CATT  **16**: Samsung, Huawei/HiSi, CATT, ZTE |
| 2.4 | 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**: Lenovo/MotM, Ericsson, ZTE,CATT  **Alt2**: Samsung |
| 2.5 | The maximum value of NMAX (number of RRC configured non-serving cell(s) for measurement/reporting)  Note: UE capability of supporting <Nmax is neither ruled out nor within the scope of 2.4 | **1**: OPPO  **>1 (specify)**: Lenovo/MotM (2), Samsung (4), AT&T, CATT, Ericsson (KMAX) , ZTE |
| 2.6 | Whether to support activation of a subset of configured non-serving cells via MAC CE | **Yes:** Apple, vivo, ZTE (@E///, this is a strong restriction, please review Section2.3.1 in our tdoc R1-2106541), CATT  **No:** LG  Ericsson: this is supported from Rel-15 for aperiodic and semi-persistent reporting. |
| 2.7 | Whether to support event-driven reporting behavior | **Yes (specify event)**: Lenovo/MotM (exceed a threshold), Xiaomi (reuse L3 events or new L1 event), Nokia/NSB, Samsung, Sony (L1 events), Qualcomm, Apple (L1 event), LG (L1 event), ZTE (L3 event), Intel, CATT  **No**: Ericsson, MTK |
| 2.8 | Synchronization and timing advance assumptions between cells  Note: This issue was identified in RAN#92 | Single TA value across cells: OPPO, MTK    Multiple TA values across cells: vivo, Futurewei, Qualcomm, Intel, [Ericsson], Apple, NTT Docomo, Sony, ZTE  Reporting timing offset in beam report: vivo  PRACH for TA measurement: Apple, NTT Docomo, ZTE |
| 2.9 | What “a UE can transmit to or receive from only a single cell” (DPS) entails  Note: This issue was identified in RAN#92 | UE-specific channels: [Huawei/HiSi], Samsung, Futurewei, Ericsson, Intel  All data and control channels: Apple, MTK, ZTE |
|  |  |  |

The following observation can be made:

* 2.1: Other than 3 companies (Huawei/HiSi, Futurewei) who prefer to conclude on 2.8 and 2.9 before confirming the WA, all other companies propose to confirm it as an agreement. Some proposals to resolve the FFS points were also made. In general, a majority sentiment is to treat inter-cell beam management the same as intra-cell – which is reasonable especially since no change in serving cell is assumed (cf. RAN#93).
  + That SSB of NSC can be used as a direct QCL source doesn’t seem possible given the current temperature (also related to issue 1.8)
* 2.2: Per agreement inRAN1#105-e, this has to be concluded yet the situation has not changed.

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

**Proposal 2.A**: On Rel.17 beam indication enhancements for inter-cell management, confirm the following working assumption as an agreement with the following refinement (highlighted in red):

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

* Rel-17 MAC-CE-based (with only one activated TCI state) and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation)
  + ~~FFS (to be decided in RAN1#106-e): Whether~~ This ~~also~~ applies to all or some of the PDCCH/PUCCH/PDSCH/PUSCH ~~only or additional target channels (e.g. UE-dedicated PDCCH/PUCCH)~~
  + ~~FFS: Whether the above is supported only for joint TCI, or~~ Supported for both joint TCI and separate DL/UL TCI ~~(including that, if separate DL/UL TCI is supported, the DL TCI and UL TCI associated with a same cell)~~
    - For separate DL/UL TCI, the DL TCI and UL TCI are associated with a same cell
  + FFS: Whether to support activation of TCI states for more than one cells simultaneously
  + ~~FFS: Whether down-selection between~~ Both MAC-CE ~~only~~ based and MAC-CE+DCI-based beam indication schemes are supported ~~is necessary~~
* The DL QCL and UL spatial relation rules already agreed for intra-cell scenario
* ~~FFS:~~ ~~The use of~~ SSB associated with a physical cell ID different from that of the serving cell is used as an indirect QCL reference for UE-dedicated PDSCH and UE-dedicated PDCCH
  + ~~FFS (to be decided in RAN1#106-e): Whether this also applies to UE-dedicated PDCCH~~
  + Note: When RS X is an indirect QCL reference of a target channel, there exists at least one other source signal on the QCL chain between RS X and 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.B**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, there is no consensus whether to support the following RS types as measurement RS or not:

* CSI-RS for mobility/RRM associated with a non-serving cell
* CSI-RS for BM configured by a non-serving cell
* CSI-RS for tracking associated with a non-serving cell
* Note: This doesn’t imply that for purposes other than Rel-17 L1-RSRP multi-beam measurement/reporting for inter-cell beam management and inter-cell mTRP, CSI-RS for BM and/or CSI-RS for tracking cannot be QCL’ed with an SSB with PCI different from serving cell.
* Note: This conclusion doesn't preclude using legacy Rel-15/16 multi-beam measurement/reporting on CSI-RS for BM QCL-ed with an SSB with PCI different from serving cell
* Note (from RAN1#105-e agreement): An RS is associated with a non-serving cell means that it is either configured for/by a non-serving cell or configured for/by a serving cell but is QCLed with a non-serving cell SSB

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** |
| Apple | Proposal 2.A: For the first FFS, we think all data and control channel should be included. There is no concept like UE-dedicated CORESET in spec. For the second FFS: we are open to separate UL/DL TCI, but we think the TCI should be associated with the same cell.  [Mod: Fixed and done] |
| OPPO | Proposal 2.A: Re the last bullet on “using SSB of another physical cell ID” as “indirect QCL reference”. I guess common understanding is we do not change the QCL rule defined in rel15/16 but just the SSB of serving cell can be replaced by SSB of another physical cell ID. To make it clear, suggest to change description in this bullet. Suggest to avoid using the wording like “indirect”. Instead, we can clearly list all the QCL reference that such a SSB can be configured:  **Proposal 2.A**: On Rel.17 beam indication enhancements for inter-cell management, confirm the following working assumption as an agreement with the following refinement (highlighted in red):  On Rel.17 beam indication enhancements for ~~L1/L2-centric~~ inter-cell beam management ~~mobility~~, support the following:   * Rel-17 MAC-CE-based and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation)   + ~~FFS (to be decided in RAN1#106-e): Whether~~ This ~~also~~ applies to PDSCH/PUSCH associated with UE-dedicated CORESETs ~~only or additional target channels (e.g.~~ and UE-dedicated PDCCH/PUCCH~~)~~   + ~~FFS: Whether the above is supported only for joint TCI, or~~ Supported for both joint TCI and separate DL/UL TCI ~~(including that, if separate DL/UL TCI is supported, the DL TCI and UL TCI associated with a same cell)~~   + FFS: Whether to support activation of TCI states for more than one cells simultaneously   + ~~FFS: Whether down-selection between~~ Both MAC-CE ~~only~~ based and MAC-CE+DCI-based beam indication schemes are supported ~~is necessary~~ * The DL QCL and UL spatial relation rules already agreed for intra-cell scenario * ~~FFS: The use of SSB associated with a physical cell ID different from that of the serving cell is used as an indirect QCL reference for UE-dedicated PDSCH and UE-dedicated PDCCH~~   + ~~FFS (to be decided in RAN1#106-e): Whether this also applies to UE-dedicated PDCCH~~   + ~~Note: When RS X is an indirect QCL reference of a target channel, there exists at least one other source signal on the QCL chain between RS X and 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~~ * Support to configure SSB associated with a physical cell ID different from that of the serving cell as QCL source as follows:   + QCL-TypeC and/or QCL-TypeD source for a TRS   + QCL-TypeD source for a CSI-RS for CSI   + QCL-TypeC and TypeD source for a CSI-RS for BM   [Mod: I see no need to list this for now especially given that the source RS discussion in RAN1 is still not concluded] |
| MediaTek | Proposal 2.A: We are okay to WA with the red changes, expect the followings:   * On the item [2.1.3], we don't see the need to activate TCI states for more than one cells if UE only can receive from or transmit to one single cell.   [Mod: It is still kept FFS]   * Regarding the definition of “UE-dedicated CORESET”, is it any CORESET associated with at least one USS set? Or only the CORESET associated with only USS set can be “UE-dedicated CORESET”?   [Mod: Please see revised version]  Proposal 2.B: Support the proposal |
| Qualcomm | For Proposal 2.A, just to clarify, the MAC-CE based beam indication refers to the single TCI activated by MAC-CE is automatically used without DCI?  [Mod: Yes, clarified now]  For Conclusion 2.B, if no consensus, how does gNB schedule P2/P3/TRS with source QCL from non-serving SSB? If the consequence is all those are not allowed, then the performance for non-serving PCI will be poor. So at least the last two bullets are needed to ensure good performance  [Mod: Please check companies views (Table 3)] |
| Lenovo/MotM | Proposal 2.A: We are OK with it in general. Regarding the “FFS: Whether to support activation of TCI states for more than one cells simultaneously”, we want to clarify the following: given no change of serving cell, is this the same as supporting activation TCI states QCLed with SSBs with more than one PCIDs at a given time?  [Mod: Yes] |
| NTT Docomo | Support proposal 2.A, 2.B. |
| Sony | **Proposal 2.A:** support the FL in principle. But same as a lot of other companies, we are also not sure the clear definition of UE-dedicated CORESET. One example could be CORESETZero is non-UE-dedicated, while other CORESETs are UE-dedicated. This interpretation doesn’t relate to USS or CSS. Perhaps we need to clarify this concept first.  [Mod: See revised version] |
| FGI/APT | Proposal 2.A: Support in principle. Share similar views as Apple that all data and control channel should be included.  Conclusion 2.B: Support |
| Ericsson | Proposal 2.A: support |
| Fraunhofer IIS/HHI | Proposal 2.A: Share the same concern as MediaTek and Sony regarding the clarification of UE-dedicated CORESET.  [Mod: See revised version] |
| Samsung | **Proposal 2.A**: Support, but we would like to keep last FFS to consider SSB as a direct QCL source.  [Mod: A number of companies have concern on this and only 2 meetings are left after this. Please check Table 3]  **Conclusion 2.B:** Support |
| Intel | **Conclusion 2.B:** For measurement, we feel that at least CSI-RS for BM in addition to SSB is needed for narrow beam tracking and switching.  [Mod: Please check companies’ views (Table 3)] |
| LG | Proposal 2.A: For the beam indication method based on MAC-CE and/or DCI, MAC-CE based beam indication may be sufficient for inter-cell BM since inter-cell beam switching may not occur so frequently and dynamically. For now, we prefer to keep original FFS on whether to down-select between MAC-CE and MAC-CE+DCI.  [Mod: Please check companies’ views in Table 3] |
| Xiaomi | Proposal 2.A: refer to the conclusion from RAN#93, RAN confirms that inter-cell mTRP in RAN1 work only considers multi-DCI and multi-PDSCH reception (per WI objective). From this conclusion, first we should focus on Multi-DCI Multi-TRP first, that means we can discuss the TRP from serving cell and from non-serving cell separately.  [Mod: That conclusion applies to item 2b (AI 8.1.2.2) not item 1 (8.1.1)  As for the TRP of serving cell, we think both joint TCI and separate TCI can be supported as well as both PDSCH and PUCCH/PUSCH. While for TRP of non-serving cell, from the above conclusion, can I understand that PUCCH/PUSCH from non-serving cell will be not considered? If yes, it means only TCI state for DL reception is needed in NSC. Thus we need to discuss how to address the FFS about joint TCI and separate DL/UL TCI in NSC. Alt 1 is to consider joint TCI state for DL reception only. Alt 2 is to only consider separate DL TCI state for DL reception only. |
| ZTE | **Proposal 2.A:** Support. Regarding indirect chain, we share the same views with Samsung. Regarding concerns on UE-dedicated channel, we think that Apple’s suggestion is much aligned with current spec.  [Mod: Please check companies’ views in Table 3]  **Conclusion 2.B:** Thanks for great efforts. In our views, at least CSI-RS for mobility/RRM can be associated with a non-serving cell.  [Mod: Please check companies’ views in Table 3] |
| Qualcomm | **For Proposal 2.A, support the latest version**  **For Conclusion 2.B, we think the last two sub-bullets are needed to make it work properly**  **• CSI-RS for BM associated with a non-serving cell**  **• CSI-RS for tracking associated with a non-serving cell**  [Mod: Please check companies’ views in Table 3] |
| Mod V26 | Revised |
| MediaTek | Proposal 2.A:  Regarding the applicable channel of the inter-cell beam indication, we still have concern if only restricted to UE-dedicated PDCCH since one CORESET may need to apply two TCI states according to legacy MAC-CE indication and Rel-17 DCI indication if it is associated with both CSS set and USS set. However, we do understand it is not possible to move all UE-dedicated and common channels to the non-serving cell but without serving cell change. Anyway, we are fine to further discuss whether there is any solution to address this issue.  [Mod: Thanks for your understanding. Please check the latest version per Apple’s comment which should also address your concern.]    Regarding the 3rd sub-bullet, it seems most of the companies agree to include the UE-dedicated PUCCH and PUSCH, thus SSB associated with a physical cell ID different from that of the serving cell can used as **a direct or indirect** spatial relation for UE-dedicated PUCCH and UE-dedicated PUSCH.   * ~~FFS:~~ ~~The use of~~ SSB associated with a physical cell ID different from that of the serving cell is used as an indirect QCL reference for UE-dedicated PDSCH and UE-dedicated PDCCH, and a direct or indirect spatial relation for UE-dedicated PUSCH and UE-dedicated PUCCH   + ~~FFS (to be decided in RAN1#106-e): Whether this also applies to UE-dedicated PDCCH~~   + Note: When RS X is an indirect QCL reference (or spatial relation) of a target channel, there exists at least one other source signal on the QCL chain between RS X and 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: This bullet only concerns DL. We can discuss UL in later round(s).] |
| Huawei, HiSilicon | Proposal 2.A: We see no need to rush to confirm the WA. After concluding two APs from RAN#92-e and replying the LS(s) from other WGs, the group would have a better understanding on inter-cell beam management. That includes the underlying assumption (i.e., what does “transmit to or receive from only a single cell” in the WID means), the required QCL rules and signaling medium, with which the WA can be revisited in a safer manner.  [Mod: At the very least, it’s quite clear that most parts of the WA are not dependent on the two newly brought up issues in RAN#92-e] |
| CATT | Proposal 2.A: support  Conclusion 2.B support |
| NEC | Support the proposal and conclusion. |
| vivo | For issue 2.8, we need to clarify some misunderstanding. The motivation of reporting timing offset between source cell and target cell in beam report is to guarantee simultaneous reception on the UE side, not for simultaneous transmission on the gNB side. Therefore, we remove our company from the queue.  For Proposal 2.A, we still don’t understand what UE-dedicated PDCCH/PUCCH is. So we add two options below to list all the possibilities.  **Proposal 2.A**: On Rel.17 beam indication enhancements for inter-cell management, confirm the following working assumption as an agreement with the following refinement (highlighted in red):  On Rel.17 beam indication enhancements for ~~L1/L2-centric~~ inter-cell beam management ~~mobility~~, support the following:   * Rel-17 MAC-CE-based (with only one activated TCI state) and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation)   + ~~FFS (to be decided in RAN1#106-e): Whether~~ This ~~also~~ applies to UE-dedicated PDCCH/PUCCH and the associated PDSCH/PUSCH ~~only or additional target channels (e.g.~~ ~~)~~   + Down-select from one of the following options for transmission and reception associated with the CORESETs configured with type 0/1/2 CSS:     - Option1: Support M/N>1 to indicate one beam for TRx associated with the CORESETs configured with type 0/1/2 CSS and another beam for TRx other channels     - Option2: The unified TCI framework is not applied for TRx associated with the CORESETs configured with type 0/1/2 CSS. The TRx associated with the CORESETs configured with type 0/1/2 CSS is based on legacy signaling   + ~~FFS: Whether the above is supported only for joint TCI, or~~ Supported for both joint TCI and separate DL/UL TCI ~~(including that, if separate DL/UL TCI is supported, the DL TCI and UL TCI associated with a same cell)~~     - For separate DL/UL TCI, the DL TCI and UL TCI are associated with a same cell   + FFS: Whether to support activation of TCI states for more than one cells simultaneously   + ~~FFS: Whether down-selection between~~ Both MAC-CE ~~only~~ based and MAC-CE+DCI-based beam indication schemes are supported ~~is necessary~~ * The DL QCL and UL spatial relation rules already agreed for intra-cell scenario * ~~FFS:~~ ~~The use of~~ SSB associated with a physical cell ID different from that of the serving cell is used as an indirect QCL reference for UE-dedicated PDSCH and UE-dedicated PDCCH   + ~~FFS (to be decided in RAN1#106-e): Whether this also applies to UE-dedicated PDCCH~~   + Note: When RS X is an indirect QCL reference of a target channel, there exists at least one other source signal on the QCL chain between RS X and 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: please check latest version per Apple’s comment. The two added alternatives need proposal 1.F to be concluded first. For instance, of M,N>1 is not supported in Rel-17, Opt1 is more suitable for later release(s).]  We are fine with the conclusion updated as below.  **Conclusion 2.B**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, there is no consensus whether to support the following RS types as measurement RS or not:   * CSI-RS for mobility/RRM associated with a non-serving cell * CSI-RS for BM associated with a non-serving cell * CSI-RS for tracking associated with a non-serving cell * For other purpose, the CSI-RS for BM/CSI-RS for tracking can still be QCL’ed with an SSB with PCI different from serving cell.   [Mod: Valid point, reworded. |
| Futurewei | Proposal 2.A: Ok to confirm the latest version of the WA.  Conclusion 2.B: Fine with the conclusion. |
| Spreadtrum | Proposal 2.A: Support the proposal.  Proposal 2.B: Based on the Note from last meeting ‘An RS is associated with a non-serving cell means that it is either configured for a non-serving cell or configured for a serving cell but is QCLed with a non-serving cell SSB’, if we agree this conclusion, only NSC SSB can be used for BM for non-serving cell.  [Mod: Correct] |
| Apple | Proposal 2.A: We suggest some changes for the first sub-bullet. It is not easy to distinguish the dedicated channel and common channel. For example, there should be only one beam to buffer data, when buffering data, there is no way for UE to identify whether the potential PDSCH is common or dedicated.   * + ~~FFS (to be decided in RAN1#106-e): Whether~~ This ~~also~~ applies to all or some of the PDCCH/PUCCH/PDSCH/PUSCH ~~only or additional target channels (e.g.~~ ~~)~~   [Mod: Done] |
| CMCC | Proposal 2.A: If SSB associated with a physical cell ID different from that of the serving cell is used as an indirect QCL reference for UE-dedicated PDSCH and UE-dedicated PDCCH, CSI-RS should be the direct QCL reference, no matter the CSI-RS is TRS or CSI-RS for CSI or CSI-RS for BM. And these CSI-RS is QCLed with a non-serving cell SSB. We suggest the following change:   * ~~FFS:~~ ~~The use of~~ SSB associated with a physical cell ID different from that of the serving cell is used as an indirect QCL reference for UE-dedicated PDSCH and UE-dedicated PDCCH   + ~~FFS (to be decided in RAN1#106-e): Whether this also applies to UE-dedicated PDCCH~~   + ~~Note: When RS X is an indirect QCL reference of a target channel, there exists at least one other source signal on the QCL chain between RS X and the target channel~~   + CSI-RS QCLed with a non-serving cell SSB is used as a direct QCL reference.   + ~~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: This possibility (any CSI-RS configured for serving cell that is QCL-ed with an SSB from non-serving cell) is supported in this bullet point – which falls within the definition of indirect QCL. It seems there is no need to explicitly mention this since it is already included in that Note (which covers more general cases of multi-linking as ZTE mentioned in the last meeting – please check the FL summary ☺).]  Conclusion 2.B: We think the measurement RS type should at least include the source RS types of *QCL-Info*. We think the proper way is UE measure the RS, and report the RS index or RS index+L1-RSRP to gNB, then gNB could configure the RS as the direct QCL reference based on UE reporting. In other words, supporting the RS as source RS implies that supporting the RS as measurement RS.  [Mod: The configured source RS doesn’t have to match the measurement RS – this has been the principle in Rel-15/16] |
| Mod V37 | Revised |
| Ericsson | Proposal 2.A: Support  Conclusion 2.B: The critical issue here is CSI-RS for beam management, and it may still be somewhat unclear what the meaning is. We note for instance that MTeK thinks that measurement can be performed on “CSI-RS for BM for serving cell associated with the non-serving SSB”. To us, this is equivalent to “CSI-RS for BM associated with NSC”. We would be fine to state there is no consensus for TRS and CSI-RS for mobility, since these are extensions to the intra-cell support, but measurements on CSI-RS for BM (and CSI-RS for CSI) are inherently supported in the intra-cell framework.  Without L1-RSRRP measurements on CSI-RS for BM, gNB Tx beam refinement in the non-serving cell is impossible.  [Mod: The wording was based on the previous agreement which could be further clarified to “configured by” – you are correct that a CSI-RS for BM configured by a SC which is QCL-ed with an SSB of a NSC (indirect) is a form of association. Revised accordingly.] |
| Mod V39 | Revision for proposal 2.B |
| MediaTek | Proposal 2.A: Okay to the revised proposal  Proposal 3: Regarding the CSI-RS for BM, we think for a CSI-RS for BM that is QCLed with an SSB with PCI different from serving cell, the measurement/reporting on the CSI-RS for BM would be treated as legacy one supported in Rel-15/16, instead of the Rel-17 inter-cell beam measurement/reporting. This conclusion doesn't preclude the use case mentioned by Ericsson, as indicated in the note of the conclusion. Maybe, the note with the following change would be more clear:   * Note: This doesn’t imply that for purposes other than Rel-17 L1-RSRP multi-beam measurement/reporting for inter-cell beam management and inter-cell mTRP, CSI-RS for BM and/or CSI-RS for tracking cannot be QCL’ed with an SSB with PCI different from serving cell   [Mod: Done] |
| Nokia | Ok with proposal 2.A |
| LG | Proposal 2.A: For the first sub-bullet, it needs to be further discussed for the details when the beam indication applies to ‘some’ of the PDCCH/PUCCH/PDSCH/PUSCH, i.e. how to select/configure the target channel(s)?  [Mod: Yes, this may need to be discussed further] |
| Ericsson | We appreciate the addition made by MTeK on the legacy reporting, which we think coincides with the interpretation by other companies. To make this even clearer, maybe we can add the note:   * Note: This conclusion doesn't preclude using legacy Rel-15/16 multi-beam measurement/reporting on CSI-RS for BM QCL’ed with an SSB with PCI different from serving cell   [Mod: Done] |
| Lenovo/MotM | Proposal 2.A: support |
| AT&T | Support proposal 2.A |
| Qualcomm | For Proposal 2.A, support  For Conclusion 2.B, it seems conflict with the original agreement. If no consensus for TRS to be associated with a non-serving cell, then based on the highlighted agreement, the TRS cannot be QCLed with non-serving SSB. But the last Note in latest Conclusion 2.B says TRS QCLed with non-serving SSB is still allowed. I am lost what the latest Conclusion 2.B means. Suggest to add the highlighted definition back to the latest version. Perhaps people may realize the conflict.  **Agreement**  On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP, decide by RAN1#106-e whether to support the following RS types as measurement RS or not:   * CSI-RS for mobility/RRM associated with a non-serving cell * CSI-RS for BM associated with a non-serving cell * CSI-RS for tracking associated with a non-serving cell   Note: If another beam metric other than L1-RSRP is supported (e.g. L3-RSRP is still FFS), the above also applies  Note: An RS is associated with a non-serving cell means that it is either configured for a non-serving cell or configured for a serving cell but is QCLed with a non-serving cell SSB  [Mod: Please check Ericsson’s comment. Re CSI-RS for BM the intention of rewording to “configured by” is to avoid precluding CSI-RS BM configured for/by serving cell (but QCL-ed with non-serving SSB). So the current wording (see above) with the note from the last meeting achieves this purpose. I can add back the Note] |

### Issue 3 (beam indication signaling medium)

Table 5 Summary: issue 3

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 3.1 | Further details on beam application time (BAT):   1. Whether different values of X/Y are needed for some scenarios – and if so, which scenarios? | **BAT for CA:**   * **Smallest SCS:** Huawei/HiSi, vivo, MTK * **Determined/indicated dynamically:** ZTE, NTT Docomo * **Determined by CC with largest delay:** Samsung, NTT Docomo (if BAT is SCS dependent value, and if CA in different SCS) * **Additional offset for cross carrier beam indication:** vivo, Nokia/NSB   **Panel-dependent beam latency:** vivo (panel activation delay), IDC, CATT (2 BATs for inter-panel and intra-panel), LGE, Samsung, FGI/APT  **Single beam application time**: OPPO, MTK |
| 3.2 | Further enhancements on ACK/NAK for DCI formats 1\_1/1\_2 with DL assignment when used for beam indication | **DCI ACK/NAK:** CATT, Apple, Xiaomi, Samsung, Intel (with higher priority for beam indication DCI ACK/NACK), ASUSTek  **DL assignment ACK/NAK, but only ACK can be used to confirm beam indication:** NEC, OPPO |
| 3.3 | Support for additional beam indication scheme for Rel-17 unified TCI framework beyond agreement to-date | **No additional beam indication scheme is supported:** CATT  **DCI formats 0\_1/0\_2 with UL grant (for UL-only TCI of separate DL/UL TCI)**: IDC, LGE, Sony, MTK, Intel, Xiaomi  **New dedicated DCI format for beam indication**:  **Group-common DCI**: Sony, Intel  **When more than one TCI codepoints are activated by MAC CE, the activated TCI state(s) for the lowest codepoint is/are applied**: Huawei/HiSi, vivo (until DCI is indicated), Convida (after MAC CE activation) |
|  |  |  |

The following observation can be made:

* ...

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

**Proposal 3.A**: On Rel-17 unified TCI, [after more inputs/discussion]

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** |
| NTT Docomo | Before we discuss BAT for CA, we think we should decide either “X ms” or “Y symbols” as BAT.   * If BAT is “X ms”, BAT is not SCS dependent, and it has less issue in CA. * If BAT is “Y symbols”, BAT is SCS dependent; for CA in different SCS, another issue is whether we should allow different BAT on different CCs. From our point of view, to enable CA operation, all CCs should maintain the same QCL type D, and hence, BAT on multiple CCs should be aligned across CCs.   Whether to allow dynamic indication for BAT by TDRA (from ZTE) is more general issue, which is not always related to CA. We prefer this proposal, but we are open to discuss. |
| Samsung | In Rel-15/Rel-16 processing latency depends on the sub-carrier spacing of the channels involved. The same principle can apply to the BAT in Rel-17. In case of cross carrier beam indication, with a common beam across the carriers and with different SCS on different carriers, the beam application time is determined based on the SCS with the longest latency. Such that a single beam application time is determined for all carriers.  Multiple BAT values may need to be indicated in some scenarios. For instance, when the beam indication indicates the need for panel switching (for a MPUE), the UE panel implementation may require additional processing time due to panel switching. Therefore, a least two BAT values (B1, B2) can be indicated to such UEs. When the beam indication doesn’t require panel switching, the UE uses the first value B1 and when it requires panel switching, the UE uses the second value B2.  Multiple BAT values may also need to be configured in other scenarios such as inter-cell beam management (e.g. one BAT value for the serving cell and another value for neighboring cells), and multi-TRP operations (e.g. two different values for the two TRPs).  Finally, the multiple BAT values can be indicated subject to the UE capability reporting including either a single minimum BAT value that applies common to all of the multiple indicated BAT values, or multiple minimum BAT values, e.g. one for each of the multiple indicated BAT values. |
| ZTE | We share the same views with NTT DOCOMO that the dynamic indication should be treated generally. |
| Mod V26 | -- |
| Huawei, HiSilicon | We added one of our proposal, which is not captured, as Issue 3.4. And we appreciate views from companies.  [Mod: The proposal was already captured in 3.3 but perhaps the wording can be more clear – replaced with your wording] |
| InterDigital | We share similar views with Samsung. We agree that at least two BAT values (B1, B2) are necessary for multi panel UE, since the processing time across multiple panels may be different, e.g., depending on how many panels are currently active for the UE. For cases of cross carrier beam indication, same principle up to Rel-16 can be reused as the current ACK transmission timing from UE has already taken the cross carrier indication into account. |
| NEC | Regarding issue 3.2, we don’t think NACK can be used for beam confirmation, as NACK for DCI format 1\_1/1\_2 with DL assignment can be caused either by unsuccessfully decoding DCI or unsuccessfully decoding PDSCH, in case of unsuccessfully decoding DCI, the applied beam may be mismatched between network (new beam) and UE (no idea of the new beam).  In addition, DCI format 1\_1/1\_2 without DL assignment can also be used for beam indication, NACK corresponding to this DCI format clearly means the DCI decoding is failed, so it’s natural the NACK corresponding to DCI format 1\_1/1\_2 not used for beam confirmation.  And UE can not know whether a DCI is with or without DL assignment if the DCI is unsuccessfully decoded, so for a unified solution, we think only ACK can be applied for beam confirmation, both for DCI 1\_1/1\_2 with and without DL assignment.  [Mod: I tend to agree] |
| Mod V36 | We will take at least issues 3.1 and 3.2 in the next round. It seems the need for multiple BAT values is a common theme. |
| MediaTek | Regarding the multiple BAT values, we prefer to discuss after related features e.g., inter-cell beam indication and MP-UE, are concluded. Especially for MP-UE, we don't even know how NW can understand whether the indicated TCI states correspond to the same UE panel or not. |
| Mod V48 | -- |

### Issue 4 (MP-UE)

Table 7 Summary: issue 4

|  |  |  |
| --- | --- | --- |
| **#** | **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, Sony (2nd priority), MTK, Intel, Apple (if UE-initiated beam reporting and UE cap are supported), [Nokia/NSB], IDC  **Opt1-2:** Huawei/HiSi, ZTE, vivo, IDC, MotM/Lenovo, Spreadturm, Sony, Samsung, CMCC, Fraunhofer IIS/HHI, AT&T, LGE, NTT Docomo, Xiaomi   * Panel ID: Huawei/HiSi, ZTE, CMCC, Fraunhofer/HHI, AT&T, LGE, NTT Docomo, Xiaomi, IDC * Resource set: Samsung   **Opt1-3:** CATT, OPPO, FGI/APT, Ericsson, Apple (if UE-initiated beam reporting and UE cap are **not** supported) |
| 4.2 | Whether to support CB-based SRS resources with different numbers of ports | **Yes**: Huawei/HiSi, CATT, OPPO, Qualcomm, [Fraunhofer IIS/HHI], Apple (only the SRS set aligned with UE selected panel can be indicated), LGE, NTT Docomo, MTK, IDC  **No**: [vivo], Ericsson |
| 4.3 | Whether to support NCB-based SRS resource sets with different numbers of resources | **Yes**: ZTE, LGE, Apple (only the SRS set aligned with UE selected panel can be indicated), IDC,CATT  **No**: [vivo], Ericsson |
| 4.4 | Support of NW-initiated panel activation/selection | **Yes**: Huawei/HiSi, IDC  **No**: Sony, [Fraunhofer IIS/HHI], Xiaomi, Apple, MTK, Ericsson,CATT |
|  |  |  |

The following observation can be made:

* ...

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

**Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection, [after more inputs/discussion]

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** |
| Mod V26 | -- |
| Mod V37 | We will take at least issue 4.3 in the next round starting from the version in the last meeting and the following guideline:  Continue to study necessary enhancements to optimize transmission from UEs with different number of max number of UL MIMO layers per panel entity |
| LG | @ Moderator, the deadline for issue 4.2 was set to #106e in the previous agreement. So, we need to conclude issue 4.2 within this meeting.  [Mod: I said ‘next round’ above. Meaning ‘round 1’. There will be rounds 2, 3, ... ☺] |
| Mod V48 | -- |
|  |  |
|  |  |
|  |  |

### Issue 5 (MPE mitigation)

Table 9 Summary: issue 5

|  |  |  |
| --- | --- | --- |
| **#** | **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, MotM/Lenovo, OPPO, Qualcomm, Convida, [Nokia/NSB], Apple, NTT Docomo  **Option 1D**: Huawei/HiSi, vivo, Spreadtrum, Sony, FGI/APT, Xiaomi, Intel  **Option 2A**: IDC, Sony, Samsung, Qualcomm, CATT, [ZTE], CMCC, MTK, Ericsson, LGE, NTT Docomo, Nokia/NSB, Intel  **Option 1A+2A**: Apple, NTT Docomo, IDC (2nd preference) |
| 5.2 | If Opt1A/D in 5.1 is supported:   * Alt1. Beam-level reporting * Alt2. Panel-level reporting | **Alt1**: Qualcomm, Convida, Apple, Ericsson, IDC (if Opt 1A+2A)  **Alt2**: Huawei/HiSi, vivo (panel ID in , Spreadturm PHR MAC CE), MotM/Lenovo, Sony, Xiaomi, LG |
| 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**: IDC, Sony, Ericsson,CATT  **Alt2**: Nokia/NSB, LG |
|  |  |  |

The following observation can be made:

* 5.1: Some companies suggest a combination between 1A and 2A as they can be complementary in purpose, in particular including V-PHR in each pair of SSBRI/CRI-RSRP. It is also pointed out that maximum reuse of Rel-15/16 reporting formats can lessen the spec burden (payload size, differential reporting).

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

**Proposal 5.A**: On Rel.17 enhancements to facilitate MPE mitigation, support to report N virtual PHR, N L1-RSRP and N SSBRIs/CRIs in one CSI reporting instance

* The Pcmax to calculate virtual PHR takes into account the P-MPR based on MPE impact, for each SSBRI /CRI report
* The pathloss to calculate virtual PHR is based on L1-RSRP measured from the corresponding SSB/CSI-RS
* The following reporting format is used:
  + The payload of the first virtual PHR value is 6 bits based on the same quantization scheme as legacy virtual PHR report.
  + The payload of the first L1-RSRP value is 7 bits based on the same quantization scheme as legacy L1-RSRP report.
  + When N>1, the remaining N-1 L1-RSRP values are reported in a differential manner
    - FFS: whether the remaining N-1 virtual PHR values are reported in a differential manner
* N can be configured in CSI–reportConfig and the maximum value of N is 4
* FFS: Whether the CSI report can be initialized by a UE triggered-event, i.e. based on the event for Rel-16 MPE mitigation scheme

Table 10 Additional inputs: issue 5

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 10**  **2) Share your inputs on the above FL proposals** |
| Apple | Support the proposal |
| MediaTek | Support the proposal |
| NTT Docomo | Support the proposal except the last bullet.  Since the report is based on CSI report framework, we think existing CSI report framework based on NW configuration/triggering can be reused.  Meanwhile, we are also supportive to consider UE initiated report. However, we think it is better to consider MAC CE based UE initiated report.  **Proposal 5.A**: On Rel.17 enhancements to facilitate MPE mitigation, support to report N virtual PHR, N L1-RSRP and N SSBRIs/CRIs in one CSI reporting instance   * The Pcmax to calculate virtual PHR takes into account the P-MPR based on MPE impact, for each SSBRI /CRI report * The pathloss to calculate virtual PHR is based on L1-RSRP measured from the corresponding SSB/CSI-RS * The following reporting format is used:   + The payload of the first virtual PHR value is 6 bits based on the same quantization scheme as legacy virtual PHR report.   + The payload of the first L1-RSRP value is 7 bits based on the same quantization scheme as legacy L1-RSRP report.   + When N>1, the remaining N-1 L1-RSRP values are reported in a differential manner     - FFS: whether the remaining N-1 virtual PHR values are reported in a differential manner * N can be configured in CSI –reportConfig and the maximum value of N is 4 * Existing NW initiated CSI report framework can be reused for the CSI report. * Support UE initiated event-triggered report via MAC CE based on Rel-16 MPE report. Further study whether the same or different (e.g., less) report content from the above CSI report are reported in MAC CE, e.g., report SSBRI/CRI + vPHR and/or L1-RSRP in MAC CE.   [Mod: Based on companies’ views, reporting via MAC-CE doesn’t seem acceptable. Removed the last bullet per your request] |
| OPPO | Proposal 5A: we do not support.  The major issue of the proposal is that the UE is able to calculate valid ‘vPHR’ for each CRI or SSBRI during beam measurement and reporting. The reason is the power parameters proposed here are not valid:   * The pathloss used here is not the right pathloss. The uplink configuration (including uplink beam, path loss RS, PC parameters) are configured to the UE through UL TCI state or joint TCI state. As in what we have agreed, the path loss RS is separately configured and PC parameters is also configured only with TCI state. Thus, when the UE measures a set of CSI-RS or SSB for beam measurement and reporting, it is no way for the UE to measure right path loss and also use the right PC parameters to calculate PHR. * The Pcmax proposed here is not valid. Pcmax is not simply Pmax – P-MPR. The Pcmax used in uplink power control is one value taken between a Pmax low bound and Pmax upper bound, and the Pmax low bound is calculated by considering all the factors, including the P-MPR for MPE issue.   To address the MPE issue properly, we shall first discuss when the so-called “MPE” issue happens for one particular beam: according the specification of RAN4, we can decide that the MPE issue happens for one particular beam happen ONLY when the determined UL Tx power hits the actual Pcmax. That means we have to use the actual PL to calculate the UL Tx power and use the actual Pcmax to calculate the PHR, the PC parameters (P0, alpha and closed loop index) also need to be actual value that are used by the UE for that particular beam. Unfortunately, those parameters proposed in 5A are not aligned with the actual values used. Only a few dB variation in PHR calculation would change the MPE story totally. If the determined Power is >= Pcmax, we would claim MPE issue happens but if the determined power is < Pcmax, we would claim no MPE issue. Therefore, we can see that the accuracy in calculated vPHR is super important. The current proposal arbitrarily introduce errors in PHR calculation.  Therefore, from our understanding, only the PHR calculated for each active TCI state gives us valid information. Since active TCI states are THE TCI states that the UE is tracking and is ready for use at any time. Each TCI state is configured with valid PL RS and PC parameter which the UE is tracking too. Furthermore, the UE has the valid Pcmax for each active TCI state.  Therefore, we propose the following alternative proposal for MPE issue, which is based on Opt1:  **Proposal 5.A-1**: On Rel.17 enhancements to facilitate MPE mitigation, support to report PHR for each activated UL TCI state or joint TCI state:   * The PHR for one TCI state is calculated based on the PL-RS and PC parameters configured to this TCI state for PUSCH channel.   [Mod: We can try this later] |
| Qualcomm | We suggest to add “MAC-CE” to solve the case that the CSI reporting beam also fails due to MPE. In this case, UE may have to start RACH to send the report via MAC-CE, like BFR MAC-CE. Otherwise, more changes may be needed to support L1 report in RACH.  **Proposal 5.A**: On Rel.17 enhancements to facilitate MPE mitigation, support to report N virtual PHR, N L1-RSRP and N SSBRIs/CRIs in one CSI reporting instance or MAC-CE   * The Pcmax to calculate virtual PHR takes into account the P-MPR based on MPE impact, for each SSBRI /CRI report * The pathloss to calculate virtual PHR is based on L1-RSRP measured from the corresponding SSB/CSI-RS * The following reporting format is used:   + The payload of the first virtual PHR value is 6 bits based on the same quantization scheme as legacy virtual PHR report.   + The payload of the first L1-RSRP value is 7 bits based on the same quantization scheme as legacy L1-RSRP report.   + When N>1, the remaining N-1 L1-RSRP values are reported in a differential manner     - FFS: whether the remaining N-1 virtual PHR values are reported in a differential manner * N can be configured in CSI –reportConfig and the maximum value of N is 4 * The CSI report or MAC-CE can be initialized by a UE triggered-event, i.e. based on the event for Rel-16 MPE mitigation scheme.   [Mod: Based on companies’ views, reporting via MAC-CE doesn’t seem acceptable] |
| Lenovo/MotM | Proposal 5.A: We are not sure how the proposal works for multi-panel UE. Can someone explain this?  [Mod: In my understanding this would be the next level detail] |
| Vivo | We do not support the propsosal. L1-RSRP based dynamic report is unnecessary.MPE detection is conducted every a few seconds. Dynamic report increases signaling overhead and also increases UE power consumption.  With UE reporting panel level P-MPR (Option 1D), it is already possible for the network to conduct the computation of UL-RSRP for UL beam selection. We don’t see any motivation to further optimize. |
| Sony | Support the FL proposal. |
| Ericsson | Do not support the proposal. Reporting DL-RSRP is not helpful to alleviate the coverage loss resulting from MPE: it only leads to additional overhead. Additionally, if the reported measurements are selected based on DL-RSRP, there is a clear risk that the relevant measurements are excluded – this is obviously true for N=1. |
| InterDigital | We added our second preference on Option 1A+2A, as an option for compromise and moving forward, suggested in the form of Proposal 5.A. |
| Samsung | Support the FL proposal.  In our view, the NW can determine a suitable UL beam for MPE mitigation if beam report includes both link quality (L1-RSRP) and PHR. Based on the reported N (L1-RSRP, PHR) pairs, the NW can estimate UL link quality (UL-RSRP), and use to determine UL beam. |
| LG | We have concern on the proposal. Given the summary of issues 5.2 and 5.3, many companies including us think that panel-level handling of MPE issue is sufficient but the FL proposal proposes beam-level handling. MPE issue happens when user body blocks some of UE antennas, i.e. panel. In this case, all beams from the blocked panel will face a same problem so we don’t understand why beam-level handling is needed if those beams are from a same panel. We would like to suggest making a decision on this point first. |
| Xiaomi | Can other SSBRI/CRI for DL and without virtual PHR reported together with such SSBRI/CRI for UL? We prefer Option 1D{ Rel.16 P-MPR based (panel-level)}+ enhanced MPUE beam report. The enhanced MPUE beam report can be triggered by a UE-triggered-event or configured with existing CSI framework. In the enhanced MPUE beam report, SSBRI/CRI with its panel ID (at least a panel without MPE issue. ) and DL L1-RSRP will be included. Thus combined with the Rel.16 P-MPR based (panel-level) and the enhanced MPUE beam report, gNB can know which beam can be used for DL and UL respectively. Thus, we prefer to support Option 1D first. And the enhanced MPUE beam report can be discussed in issue 4 in which whether to add a panel ID or not is discussed. |
| ZTE | Support the original FL proposal, rather than the latest one. In our views, UE-initialized reporting is essential. Since MPE is up to UE implementation, and it is difficult for gNB to decide when or how frequency to trigger the corresponding report.  [Mod: Added back as an FFS, that’s the best I can do for now]  Also we identify the issues raised by QC and NTT DOCOMO. If possible, we may mention that ‘down-selection or support both of MAC-CE or UCI based reporting’ may be discussed separately in the next round. |
| Qualcomm | We are not ok for removing UE triggered MPE report in MAC-CE via RACH. Otherwise, how does it work if the CSI reporting UL beam itself failed? We are fine to leave the MAC-CE design details to RAN2 to save RAN1 time.  [Mod: Added back as an FFS, that’s the best I can do for now] |
| Convida Wireless | OK with the proposal. OPPO’s proposal is also good. |
| Mod V26 | Revised |
| MediaTek | Regarding the concern from Ericsson, what if the SSB/CSI-RS resources are selected based on vPHR instead of DL-RSRP, it shall be able to avoid the risk. |
| Huawei, HiSilicon | Proposal 5.A: We share similar view as vivo and Xiaomi, and we do not support the proposal. |
| CATT | Do not support the proposal. how to use DL-RSRP and VPHR reported by UE to select UL beam need to be implicitly explained. |
| Spreadtrum | Do not support the proposal. We are not clear why L1-based MPE reporting is proposed rather than MAC CE based solution. |
| CMCC | We are not clear of the benefit of combining 1A and 2A.  [Mod: Other than for compromise, in my understanding, the proponents argue that PHR reporting should be improved together (adding beam-specific PHR with MPE-targeted reporting to derive UL RSRP, e.g. DL RSRP – PMPR, to ensure the best performance for MPE mitigation – the current PHR is not beam-specific.)] |
| Mod V37 | The current situation indicates that companies positive for significant enhancements (1A and 2A) cannot agree among themselves. Perhaps it is time to consider Opt 1D (basically no enhancement over Rel-16 PHR-based with UE-specific P-MPR appended) and what can be added on top of it.  For the next round. I recommend the proponents of option 1A and 2A to start exploring this route. |
| Nokia/NSB | Support the proposal. |
| Lenovo/MotM | Do not support the proposal.  We do not know how it works for MPUE. Including L1-RSRP and SSBRI/CRI in the report does not tell gNB the panel used for measurement. If this is left as UE implementation, the gNB and UE may not have the same understanding regarding the panel UE used for TX and RX. Some UL information is needed. |
| Qualcomm | We are not fine to move event triggered report to FFS and remove report in MAC-CE. As mentioned above, the proposal does not work when the CSI reporting UL beam fails  [Mod: I think proposal 5.A (based on 1A and 2A) will not go through. Check my Mod V37 comment for the next direction.] |
| Mod V48 | -- |

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

Table 11 Summary: issue 6

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views on specific candidate schemes** |
| 6.1 | Group 1: Beam management with reduced DL signaling to reduce latency   * Opt 1-A. UE-initiated beam selection/activation based on beam measurement and/or reporting (without beam indication or activation from NW) * Opt 1-B. Beam measurement/reporting/refinement/selection triggered by beam indication (without CSI request) * Opt 1-C. Aperiodic beam measurement/reporting based on multiple resource sets for reducing beam measurement latency | **Opt 1-A**: ZTE, vivo, Futurewei, OPPO, Qualcomm, MTK, Ericsson, Apple, LGE, NTT Docomo, Nokia/NSB, IDC (only within an indicated TCI state group, e.g., by a group-ID)  **Opt 1-B**: ZTE, IDC, Samsung, Qualcomm, OPPO  **Opt 1-C**: ZTE, CATT, Qualcomm, Samsung |
| 6.2 | Group 2: Reducing activation delay of TCI states and PL-RSs (including other WGs, e.g. RAN4)   * Opt 2-A: Latency reduction for MAC CE based TCI state activation, or frequency/time/beam tracking * Opt 2-B: Latency reduction for MAC CE based PL-RS activation * Opt 2-C: 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-A**: ZTE (independent pools for a time period), vivo, OPPO, Qualcomm, Ericsson, Apple, NTT Docomo, Nokia  **Opt 2-B**: ZTE (independent pools for a time period), vivo, Qualcomm  **Opt 2-C**: Ericsson  **Discuss first in RAN4:** IDC, Samsung  **Send LS to RAN4**: MTK, Ericsson |

The following observation can be made:

* ...

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

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

Table 12 Additional inputs: issue 6

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 12**  **2) Share your inputs on the above FL proposals** |
| Ericsson | Opt 1-C is supported from Rel-15. One DCI can point at one aperiodic trigger state, which points at two report settings. These two report settings point at two different aperiodic CSI-RS resource sets ,and where the slot offset is defined differently for the two aperiodic CSI-RS resource sets. |
| ZTE | Generally, we think that the down-selection should be based on the popularity of each candidates, and whether the companies’ proposal can be converged. If whether to send an LS to RAN4 is controversial, we may focus on group-1 firstly.  From ZTE perspective, our first preference is Opt 1-C. For Opt 1-A, we think that gNB response, e.g., UE initialized beam activation by legacy UE reporting and then DCI indication for confirmation, is necessary. For Opt 1-B, we slightly prefer to focus on TRS firstly for narrowing the scope. |
| Mod V26 | -- |
| InterDigital | We share similar views with ZTE, in terms of topic prioritization, that we can focus on Group 1 first.  For Opt 1-A, we believe the UE-initiated beam selection/activation (if adopted) should be at least restricted within a certain set of TCI states (not freely chosen by the UE), meaning at least a certain degree of controlling a candidate beam set (e.g., TCI state group) indicated to the UE should be given to the gNB side, for reliability of overall beam management procedures. |
| Mod V37 | For the next round we will focus on Group 1 and see if we can progress. |
| Mod V48 | -- |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | R1-2106864 | Summary of offline discussion on unified TCI and inter-cell beam management | Moderator (Samsung) |
| 2 | R1-2106463 | Enhancements on multi-beam operation in Rel-17 | Huawei, HiSilicon |
| 3 | R1-2106541 | Enhancements on Multi-beam Operation | ZTE |
| 4 | R1-2106571 | Further discussion on multi beam enhancement | vivo |
| 5 | R1-2106640 | Remaining Details on Enhancements for Multi-beam Operation | IDC, Inc. |
| 6 | R1-2106666 | Enhancements on Multi-beam Operation | Lenovo, Motorola Mobility |
| 7 | R1-2106685 | Enhancements on Multi-beam Operation | Spreadtrum Communications |
| 8 | R1-2106789 | Further enhancement on multi-beam operation | Sony |
| 9 | R1-2106864 | Moderator summary for multi-beam enhancement | Moderator (Samsung) |
| 10 | R1-2106865 | Multi-Beam Enhancements | Samsung |
| 11 | R1-2106935 | Discussions on enhancements on multi-beam operation | CATT |
| 12 | R1-2107029 | Enhancements on Multi-beam Operation | Fujitsu |
| 13 | R1-2107085 | Enhancement on multi-beam operation | FUTUREWEI |
| 14 | R1-2107143 | Discussion on multi-beam operation | NEC |
| 15 | R1-2107203 | Enhancements on Multi-beam Operation | OPPO |
| 16 | R1-2107297 | Discussion of enhancements on multi-beam operation | FGI, Asia Pacific Telecom |
| 17 | R1-2107323 | Enhancements on Multi-beam Operation | Qualcomm Incorporated |
| 18 | R1-2107390 | Enhancements on multi-beam operation | CMCC |
| 19 | R1-2107464 | Enhancements on multi-beam operation | Fraunhofer IIS, Fraunhofer HHI |
| 20 | R1-2107485 | Enhancement on multi-beam operation | MTK Inc. |
| 21 | R1-2107570 | Enhancements to Multi-Beam Operations | Intel Corporation |
| 22 | R1-2107628 | Enhancements on Multi-beam Operation | Ericsson |
| 23 | R1-2107689 | Enhancements on Multi-beam operations | AT&T |
| 24 | R1-2107718 | Views on Rel-17 Beam Management enhancement | Apple |
| 25 | R1-2107814 | Enhancements on Multi-beam Operation | LG Electronics |
| 26 | R1-2107838 | Discussion on multi-beam operation | NTT DOCOMO, INC. |
| 27 | R1-2107893 | Enhancements on multi-beam operation | Xiaomi |
| 28 | R1-2108019 | Enhancements on Multi-beam Operation | Convida Wireless |
| 29 | R1-2108052 | Enhancements on Multi-beam Operation | Nokia, Nokia Shanghai Bell |
| 30 | R1-2106548 | Further details on Multi-beam and Multi-TRP operation | ZTE |
| 31 | R1-2106671 | HARQ feedback of SPS PDSCH reception in multi-DCI based multiple TRPs | Lenovo, Motorola Mobility |
| 32 | R1-2106872 | Additional enhancements for multi-beam | Samsung |
| 33 | R1-2107210 | Discussion on further enhancements for multi-beam operation | OPPO |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |