**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:

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

This summary includes the following:

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

## Summary of companies’ inputs

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

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

Table 1 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** |
| 1.1 | 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), APT, MTK (with changes), Ericsson (with changes), Apple (with changes), NTT Docomo (with changes)  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 (21): Lenovo/MotM, Spreadtrum, Samsung, NEC, OPPO, FGI/APT, CMCC, Fraunhofer IIS/HHI, Intel, AT&T, Convida, Nokia/NSB, Ericsson, Qualcomm, IDC, Xiaomi, CATT * No (5): vivo, MTK, Huawei/HiSi, Futurewei   **Some** CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)   * Yes (14): Sony (rep ON), Samsung (rep ON), OPPO (rep ON), FGI/APT, CMCC (rep ON), Fraunhofer IIS/HHI, Intel, AT&T, ZTE, Ericsson (if TCI state is not configured), Xiaomi (rep ON), Fujitsu * No (7): vivo, Spreadtrum, MTK, IDC, Huawei/HiSi, Futurewei   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 (6): Apple, Ericsson, OPPO (but not all), Sony, ZTE, MTK * 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 (10): Spreadtrum, Sony, Intel, Nokia/NSB, FGI/APT, Lenovo/MotM, Samsung * No (5): Huawei/HiSi, vivo, MTK, Futurewei |
| 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 (19):** Samsung, Fujitsu, NEC, OPPO, Qualcomm, Fraunhofer IIS/HHI, MTK, Ericsson, Xiaomi, Convida, Nokia/NSB, ZTE, IDC, CMCC, Huawei/HiSi, AT&T  **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  **No:** OPPO (configured per SRS resource)  1.4.2:  **Yes**: Samsung, LGE, NTT Docomo  **No:** ZTE, vivo, OPPO, MTK, Intel, Ericsson |
| 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, AT&T, Xiaomi, Nokia/NSB, Apple, Qualcomm, NEC, Sony, IDC, vivo, Fujitsu, CATT, Lenovo/MotM   + **No**: Ericsson, Sony , Convida * sTRP:   + **Yes**: CATT (other target DL RS), AT&T, IDC, vivo, IDC   + **No**: Samsung (ok for Rel-18), MTK * CORESET beam diversity:   + **Yes**: Futurewei, Qualcomm, Huawei/HiSi   + **No**: Samsung (ok for Rel-18), MTK * MPUE:   + Yes: LGE   + No: MTK   1.5.2:   * M=2, N=2: vivo, Samsung, NEC, OPPO, Nokia/NSB, MTK * M=1, N=1: Convida   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 * One codepoint associated with M or N TCI states (sDCI-based): Lenovo/MotM, APT, Fraunhofer IIS/HHI, MTK, Apple, Qualcomm, NEC, AT&T, Futurewei * RRC-based grouping: Intel, Nokia/NSB, ZTE, IDC, Fujitsu, LGE, CATT |
| 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  **Alt2**: CMCC, Ericsson, Futurewei, Huawei/HiSi, Fraunhofer IIS/HHI |
| 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   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   CSI-RS for CSI   * **Yes:** Sony, CMCC * **No:** Spreadtrum, Samsung, MTK, Apple |
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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 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
* 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**: 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
  + Some CSI-RS resources for BM
    - FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic, repetition ‘ON’
  + 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, repetition ‘ON’

**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,

* 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
* In RAN1#106-e, discuss further and conclude on the UE behaviour when “beam alignment” does not occur

**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

**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

Table 2 Additional inputs: issue 1

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 1**  **2) Share your inputs on the above FL proposals** |
| 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. |
| 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   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   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. |
| 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:  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.   **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   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   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. 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. |
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### Issue 2 (inter-cell beam management)

Table 3 Summary: issue 2

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| **#** | **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) * Data only:   2.1.2:   * Joint: Samsung, Ericsson, NTT Docomo * Separate: MTK (DL NSC, UL SC), Ericsson, NTT Docomo, Samsung (DL and UL associated with the same cell)   2.1.3:   * One cell: CATT, OPPO, MTK, Apple * 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   2.1.5:   * SSB Indirect QCL only: Huawei, Sony, OPPO, CMCC, Ericsson, Apple * SSB Direct+Indirect QCL: Samsung, NTT Docomo, MTK |
| 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/MoM, Fujitsu, Sony, LG, ZTE, Spreadtrum * **No**: Nokia/NSB, Samsung, Xiaomi, OPPO, MTK, Intel   CSI-RS for BM associated with NSC:   * **Yes**: Nokia/NSB, Ericsson, AT&T, Spreadtrum, Intel * **No**: Samsung, OPPO, Xiaomi, MTK   CSI-RS for tracking (TRS) associated with NSC:   * **Yes**: Lenovo/MoM * **No**: Samung, OPPO, Xiaomi, Spreadtrum, MTK |
| 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 |
| 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  **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 |
| 2.6 | Whether to support activation of a subset of configured non-serving cells via MAC CE | **Yes:** Apple, vivo  **No:** |
| 2.7 | Whether to support event-driven reporting behavior | **Yes (specify event)**: Lenovo/MoM (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  **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  Reporting timing offset in beam report: vivo  PRACH for TA measurement: Apple, NTT Docomo |
| 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  All data and control channels: Apple, MTK |
|  |  |  |

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 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~~

**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

Table 4 Additional inputs: issue 2

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 3**  **2) Share your inputs on the above FL proposals** |
| 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. |
| 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 |
| 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. * 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”?   Proposal 2.B: Support the proposal |
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### Issue 3 (beam indication signaling medium)

Table 5 Summary: issue 3

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| **#** | **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 * **Determined by CC with largest delay:** Samsung * **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  **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  **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:**  **DCI formats 0\_1/0\_2 with UL grant (for UL-only TCI of separate DL/UL TCI)**: IDC, LGE, Sony, MTK, Intel  **Group-common DCI**: Sony, Intel  **TCI state apply corresponds to lowest activated code point**: Huawei/HiSi, vivo (until DCI is indicated), Convida (after MAC CE activation) |
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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

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 5**  **2) Share your inputs on the above FL proposals** |
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### Issue 4 (MP-UE)

Table 7 Summary: issue 4

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| **#** | **Issue** | **Companies’ views** |
| 4.1 | Whether to support the following measurement/reporting scheme for UE-initiated panel activation/selection:   * Opt1-1: A panel entity corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance   + The correspondence between a panel entity and a reported CSI-RS and/or SSB resource index is informed to NW   + Note: the correspondence between a CSI-RS and/or SSB resource index and a panel entity is determined by the UE (analogous to Rel-15/16) * Opt1-2: A panel entity is referring to a new panel ID within CSI/beam reports   + FFS: Detailed design of the new panel ID including the information conveyed by the new panel ID   + Note: The association between the new panel ID and the panel entity is determined by the UE * Opt1-3: No additional specification support | **Opt1-1:** Huawei/HiSi, Sony (2nd priority), MTK, Intel, Apple (if UE-initiated beam reporting and UE cap are supported), [Nokia/NSB]  **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 * 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  **No**: [vivo] |
| 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)  **No**: [vivo] |
| 4.4 | Support of NW-initiated panel activation/selection | **Yes**: Huawei/HiSi, IDC  **No**: Sony, [Fraunhofer IIS/HHI], Xiaomi, Apple, MTK |
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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

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 7**  **2) Share your input on the above FL proposals** |
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### Issue 5 (MPE mitigation)

Table 9 Summary: issue 5

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

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

Table 11 Summary: issue 6

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| **#** | **Issue** | **Companies’ views on specific candidate schemes** |
| 6.1 | 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  **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

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 12**  **2) Share your inputs on the above FL proposals** |
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# References

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| 2 | R1-2106463 | Enhancements on multi-beam operation in Rel-17 | Huawei, HiSilicon |
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| 5 | R1-2106640 | Remaining Details on Enhancements for Multi-beam Operation | IDC, Inc. |
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| 15 | R1-2107203 | Enhancements on Multi-beam Operation | OPPO |
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| 17 | R1-2107323 | Enhancements on Multi-beam Operation | Qualcomm Incorporated |
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| 32 | R1-2106872 | Additional enhancements for multi-beam | Samsung |
| 33 | R1-2107210 | Discussion on further enhancements for multi-beam operation | OPPO |
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