**3GPP TSG RAN WG1 #104b-e R1-2103220**

**e-Meeting, April 12th – 20th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary for multi-beam enhancement

**Document for:** Discussion and Decision

## Introduction

In this summary, the term “item 1” refers to the first item in the Rel.17 NR FeMIMO WID, i.e. multi-beam enhancement:

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

This summary includes the following:

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

## Summary of companies’ inputs

The listed issues are structured primarily to facilitate some progress on pending issues identified in the agreements especially in 103-e and 104-e (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 | 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 | SSB, with TRS as QCL Type-A source RS   * **Yes (12):** vivo, Lenovo/MoM, Samsung, NTT Docomo, ZTE, MTK, AT&T, Qualcomm, Xiaomi, Convida, CATT * **No (11):** Huawei, HiSi, OPPO, Spreadtrum, APT/FGI, Intel, Nokia/NSB, Sony, Futurewei   SRS for BM, optionally with TRS as QCL Type-A source RS   * **Yes (11):** IDC, vivo, Lenovo/MoM, Samsung, Nokia/NSB, ZTE, Apple, Convida, Xiaomi, CATT, Spreadtrum * **No (13):** Ericsson, Huawei, HiSi, OPPO, Intel, LGE, APT/FGI, Sony, Futurewei, Fraunhofer IIS/HHI   CSI-RS for CSI   * **Yes (7):** CMCC, Huawei, HiSi, ZTE, Sony, AT&T, NTT Docomo * **No (7):** vivo, Spreadtrum, MTK, APT/FGI, Nokia/NSB |
| 1.2 | Additional source RS type for UL TX spatial filter  Note: SSB, SRS for BM, CSI-RS for tracking (TRS), and CSI-RS for BM have been agreed | Non-BM CSI-RS other than for tracking   * **Yes (5):** CMCC, ZTE, Sony, Huawei, HiSi, * **No (7):** vivo, Apple, MTK, Nokia/NSB, Qualcomm, Futurewei, Spreadtrum   Non-BM SRS   * **Yes (8):** CMCC, Spreadtrum, ZTE, Sony, Nokia/NSB, Huawei, HiSi, * **No (8):** Apple, MTK, APT/FGI, Qualcomm, Lenovo/MoM, Futurewei |
| 1.3 | Switching between joint and separate DL/UL TCI   * Alt1. A UE can be dynamically indicated with either joint DL/UL TCI or separate DL/UL TCI * Alt2A. A UE can be configured with either joint DL/UL TCI or separate DL/UL TCI via RRC signaling * Alt2B. A UE can be configured with either joint DL/UL TCI, separate DL/UL TCI, or both via RRC signaling * Alt3. A UE can be configured with either joint DL/UL TCI or separate DL/UL TCI via MAC CE signaling | **Alt1 (17)**: Lenovo/MoM, Nokia/NSB, Spreadtrum, CATT, APT/FGI, Xiaomi, Sony, AT&T, Apple, MTK, ZTE, Futurewei, Convida, Intel  **Alt2A (6)**: Ericsson, NTT Docomo, LGE, NEC, Huawei, HiSi  **Alt2B (2)**: vivo, ZTE  **Alt3 (11)**: CMCC, Samsung, NTT Docomo, Huawei, HiSi, CATT, Xiaomi, Intel, Qualcomm, NEC, Convida. |
| 1.4 | Whether Rel-17 DL and, if applicable, joint TCI also applies to the following signals.   * If not applicable, how to provide DL QCL information for those signals   Note: UE-dedicated reception on PDSCH and all/subset of CORESETs have been agreed | CSI-RS resource for CSI:   * **Yes (21)**: Lenovo/MoM, Ericsson, Nokia/NSB, OPPO, Spreadtrum, MTK, APT/FGI, Intel, Convida, AT&T, Samsung, Apple (at least for default AP-CSI-RS beam), Sony, Qualcomm, Xiaomi, NTT Docomo, Intel, CATT * **No (3)**: Huawei, HiSi, Futurewei (need further discussion)   Some CSI-RS resource(s) for BM (if so, which one(s), e.g. aperiodic, repetition ‘ON’)   * **Yes (16)**: Ericsson, Nokia/NSB, OPPO, MTK, APT/FGI, Intel, AT&T, Samsung, Apple (at least for default AP-CSI-RS beam), Sony (at least for repetition ‘ON’), Qualcomm, Xiaomi, NTT Docomo, Intel * **No (3)**: Huawei, HiSi, Futurewei (need further discussion, depending on whether the resource is repeated or not) , Spreadtrum   CSI-RS for tracking:   * **Yes (10)**: Lenovo/MoM, Ericsson, Spreadtrum, AT&T, Nokia/NSB, Sony, Qualcomm, CATT * **No (5)**: Huawei, HiSi, MTK, Futurewei, NTT Docomo |
| 1.5 | Whether Rel-17 UL and, if applicable, joint TCI also applies to the following signals.   * If not applicable, how to provide UL TX spatial reference information for those signals | Some SRS resources or resource sets for BM:   * **Yes (14)**: Lenovo/MoM, Ericsson, OPPO, MTK, Intel, APT/FGI, Nokia/NSB, Sony, Qualcomm, Xiaomi, Convida * **No (3)**: Huawei, HiSi, Futurewei (need further discussion) , Spreadtrum (reuse R15 TCI framework) |
| 1.6 | Setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index): In addition to association with UL channel/RS,   * Alt1. The setting of (P0, alpha, closed loop index) is also associated with UL or (if applicable) joint TCI state * Alt2. The setting of (P0, alpha, closed loop index) is included with UL or (if applicable) joint TCI state * Alt3. The setting of (P0, alpha, closed loop index) is neither associated with nor included in UL or (if applicable) joint TCI state * Alt4. The setting of (P0, alpha, closed loop index) is determined as in Rel-16 without enhancement | **Alt1 (11)**: Lenovo, CMCC (PUCCH), Nokia/NSB, NTT Docomo, Spreadtrum, CATT, ZTE, OPPO (PUSCH, PUCCH), Qualcomm, Futurewei  **Alt2 (6)**: IDC, Samsung, Intel (at least PUCCH), Apple, Qualcomm, LGE  **Alt3 (5)**: Fraunhofer IIS/HHI, CMCC (PUSCH – SRI, SRS – SRSResourceSet), Ericsson (for P0 and alpha), Sony,  **Alt4 (5)**: vivo, OPPO (SRS), MTK, Huawei, HiSi |
| 1.7 | Path-loss measurement (PL RS):   * Alt1. PL-RS can be included in UL TCI state or (if applicable) joint TCI state.   + FFS: Whether it is always included or not. If not included, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state. * Alt2. PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state   + FFS: Exact association mechanism   + FFS: Whether it is always associated or not. If not associated, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state * Alt3. The periodic DL-RS used as a source RS for determining spatial TX filter can be used as PL-RS. In case the periodic DL-RS used as a source RS for determining spatial TX filter is not used as PL-RS, reuse Rel.16 procedure with the same signaling structure (MAC CE+SRI field in UL-related DCI) to indicate PL-RS for UL transmission with minimum enhancement (e.g. pertaining to the use for PUCCH, or using default PL-RS)   + PL-RS is not additionally configured in or associated to UL TCI state or (if applicable) joint TCI state * Alt4. UE calculates path-loss based on periodic DL RS configured as the source RS or a periodic QCL-Type-D/spatialRelationInfo source of the source RS in UL TCI state or (if applicable) joint TCI state   + FFS: Whether UE can calculate path-loss based on DL periodic RS for path-loss calculation for UL RS in the UL TCI | **Alt1 (10)**: IDC, Fraunhofer IIS/HHI, Ericsson (if UL RS in TCI state), NTT Docomo, OPPO, Intel (at least PUCCH), Qualcomm, AT&T, LGE  **Alt2 (14)**: Lenovo/MoM, CMCC, NTT Docomo, Huawei, HiSi, Spreadtrum, CATT, ZTE, MTK, Futurewei, Sony, Nokia/NSB  **Alt3 (1)**: vivo  **Alt4 (3)**: Ericsson (if DL RS in TCI state), Samsung, Apple, |
| 1.8 | [Based on offline discussion, cf. Yuki, *reformulated for better clarity*] Carrier aggregation  For TCI state(s) shared across a set of CCs (that is associated with the same gNB beam):   * Alt1: CC-specific QCL-TypeD RS can be determined from the shared TCI state(s). The determined QCL-TypeD RSs for the set of CCs are further associated with a same QCL-TypeD RS. * Alt2: A single QCL-TypeD RS is determined from the shared TCI state(s), and support enhanced QCL chain: support “i) only”, “ii) only”, or “both i) and ii)” from the following:   + i) the QCL type A TRS and, if any, QCL type D TRS, in the same/different CSI-RS resources   + ii) the QCL type A TRS and, if any, QCL type D SSB | **Alt1 (10)**: Nokia/NSB, NTT Docomo, Intel, Apple, APT/FGI, CATT, Huawei, HiSi,  **Alt2 (7)**: vivo, Samsung, NTT Docomo, ZTE, MTK, Sony (“i only”), Qualcomm (both i and ii) , Spreadtrum |
| 1.9 | For separate TCI, UL TCI state pool  Alt1: Shared pool with joint/DL TCI state  Alt2: Separate pool | **Alt1 (9)**: vivo, Samsung, Spreadtrum, ZTE, MTK, Xiaomi, Intel, Qualcomm, Convida,  **Alt2 (11)**: Fraunhofer IIS/HHI, CMCC, Ericsson, OPPO, Futurewei, Sony, Lenovo/MoM, Huawei, HiSi |
| 1.10 | TCI state pool for CA  Alt1: Separate, per CC  Alt2: Shared among all CCs  Note: This can be better formulated after #1.8 is finalized | **Alt1 (8):** Nokia/NSB, CATT, OPPO, Futurewei, Huawei, HiSi, LG  **Alt2 (11):** vivo, Samsung, Spreadtrum, ZTE, MTK, Xiaomi, Intel, Apple, Qualcomm, Sony, NTT Docomo |
| 1.11 | Maximum value of M (DL) and N (UL) along with the use case(s) | Max M:   * **1**: Samsung (depending on issue 3 outcome), NTT Docomo (1st priority), Spreadtrum, ZTE (high priority), MTK, Convida, OPPO, Apple (sTRP), Sony (sTRP), Fraunhofer IIS/HHI (sTRP), CATT (S-TRP) * **2**: Nokia/NSB (1st priority), Apple(mTRP), APT/FGI, Sony (mTRP), Lenovo/MoM(mTRP), Xiaomi, Fraunhofer IIS/HHI (mTRP), CATT (M-TRP), AT&T * **>2 (specify)**: Vivo, Futurewei, Qualcomm, LGE, Nokia/NSB (2nd priority), AT&T   Max N:   * **1**: Samsung (depending on issue 3 outcome), NTT Docomo (1st priority), Spreadtrum, ZTE (high priority), MTK, Convida, OPPO, Apple (sTRP), Sony (sTRP) , Fraunhofer IIS/HHI (sTRP), CATT (S-TRP) * **2**: Nokia/NSB (1st priority), Apple(mTRP), APT/FGI, Sony (mTRP), Lenovo/MoM(mTRP), Fraunhofer IIS/HHI (mTRP), CATT (M-TRP), AT&T * **>2 (specify)**: Vivo, Futurewei, Qualcomm, LGE, Nokia/NSB (2nd priority), AT&T   Clarify whether M>1 or N> 1implies simultaneous reception with different DL QCL(s) or transmission with different UL spatial filter(s): Huawei, HiSi |
| 1.12 | TCI for non-UE-dedicated reception on PDSCH and all/subset of CORESETs  Alt1: Extend (use) Rel-17 unified TCI  Alt2: Reuse Rel-15/16 TCI | **Alt1**: vivo, Samsung, Qualcomm, Futurewei, Huawei, HiSi  **Alt2**: Apple (modify Alt2 as “reuse Rel-15/16 QCL assumption”, since many cases are for idle mode UE and there is no TCI.) |

The following observation can be made:

* Based on the discussion in RAN1#104-e and previous meetings, RAN1 should strive for concluding most of the above issues.
* (1.1) Additional source RS for DL QCL Type D: Based on the outcome of the offline discussion (primarily on SSB and SRS for BM), the pros and cons have been well-understood. There is no consensus in supporting additional source RS types in this case (approximately equal number of supporters and opponents).
* (1.2) Additional source RS for UL TX spatial reference: There is no consensus in supporting additional source RS types in this case (more opponents than supporters).
* (1.3) Switching between joint and separate TCI: Since separate TCI is motivated by, e.g. MPE and UL MPUE, most companies find semi-static switching limiting as evident by larger support for Alt1 and Alt3. To reach a conclusion on this matter, we will focus our discussion to select between Alt1 and Alt3
* (1.4, 1.5) Strong majority on applying Rel-17 unified TCI on CSI-RS for CSI, some CSI-RS for BM, TRS, and some SRS for BM
* (1.6) UL PC: Strong majority on Alt1
* (1.7) PL-RS: Alt1 and Alt2 are supported by most companies. The pros and cons between Alt1 and Alt2 may need more discussion in this meeting to reach a conclusion.
* (1.10) TCI pool for CA: Majority support on Alt2 (shared pool among CCs). This issue may be related to 1.8. It may be beneficial to discuss 1.8 and 1.10 together.

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

**Conclusion 1.1**: On Rel.17 unified TCI framework, in RAN1#104b-e:

* At least for DL UE-dedicated reception on PDSCH and all/subset of CORESETs in a CC, there is no consensus in supporting SSB, CSI-RS for CSI, and/or SRS for BM as source RS types for DL QCL Type D
* At least for dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources in a CC, there is no consensus in supporting non-BM CSI-RS other than for tracking and non-BM SRS as source RS types for UL TX spatial filter reference

**Proposal 1.2**: On Rel.17 unified TCI framework, in RAN1#104b-e, further discuss to down-select or combine from the following two alternatives for switching between joint and separate DL/UL TCI (note: the text below is based on the agreed description in RAN1#104-e):

* Alt1. A UE can be dynamically indicated with either joint DL/UL TCI or separate DL/UL TCI
  + Details on dynamic indication are FFS
* Alt3. A UE can be configured with either joint DL/UL TCI or separate DL/UL TCI via MAC CE signaling
  + Details on how this is signaled in relation to TCI activation are FFS

The support for joint DL/UL TCI and/or separate DL/UL TCI is subject to UE capability

**Proposal 1.3**: On Rel.17 unified TCI framework,

* DL or, if applicable, joint TCI can also apply to the following signals:
  + CSI-RS resources for CSI
    - FFS: Supported settings, e.g. aperiodic-only, some vs all CSI-RS resources for CSI
  + Some CSI-RS resources for BM
    - FFS: Supported settings, e.g. one CSI-RS resource set with repetition ‘ON’, or repetition of both ‘ON’ and ’OFF’, aperiodic-only
  + FFS: Whether legacy TCI state should be applied to the DL signals not allowed for separate DL or joint TCI state.
* UL or, if applicable, joint TCI can also apply to some SRS resources or resource sets for BM
  + FFS: Whether legacy spatial relation state should be applied to the UL signals not allowed for separate UL or joint TCI state

**Proposal 1.4**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework,

* For PUSCH, the setting of (P0, alpha, closed loop index) is also associated with UL or (if applicable) joint TCI state
* For PUCCH, the setting of (P0, alpha, closed loop index) is also associated with UL or (if applicable) joint TCI state
* [For SRS, the setting of (P0, alpha, closed loop index) ...]
* Note: It has been agreed that the setting of (P0, alpha, closed loop index) is associated with UL channel or UL RS (therefore the setting is channel- and signal-specific)

**Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#104b-e, further discuss and select between the following two alternatives for path-loss measurement (note: the text below is based on the agreed description in RAN1#104-e):

* Alt1. PL-RS can be included in UL TCI state or (if applicable) joint TCI state.
  + If not included, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state.
* Alt2. PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state
  + FFS: Exact association mechanism
  + If not associated, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state
* Support of PL-RS associated with or in UL TCI state or (if applicable) joint TCI state is an optional feature

Table 2 Additional inputs: issue 1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Apple | Our view is provided |
| APT/FGI | We have added and updated our views above. |
| Nokia/NSB | Our view is added.  Issue 1.1: we assume Rel-15/16 like TCI state will be configured between SSB and TRS. And as agreement, Rel-17 type of TCI can be configured with TRS as QCL source. So as a result, direct association between SSB and Rel-17 TCI would not be necessary  Issue 1.9: we don’t see a big difference on physical layer operation between alt 1 and alt 2. |
| Sony | Input our additional views and modify some. |
| ZTE | Our views are provided. Issue 1.12 is unclear to us, and some clarification on motivation seems to be needed. |
| Futurewei | Our additional views are added.  Issue 1.8: We support “A single QCL-TypeD RS is determined from the common TCI state(s)”, however, we would like to have some clarifications on i) and ii).  Issue 1.11: The categories of “2” and “>2” should be grouped together as a single category, e.g., “>1”.  [Mod] Will do so in the next round |
| Mod | Moderator proposals have been added |
| Apple2 | For proposal 1.3, we would like to add a note to clarify that the intention is to to create standalone aperiodic TRS.  **Proposal 1.3**: On Rel.17 unified TCI framework,   * DL or, if applicable, joint TCI can also apply to the following signals:   + CSI-RS resources for CSI   + Some CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)   + CSI-RS for tracking   + Note: aperiodic TRS should be QCLed with a periodic TRS with regard to QCL-TypeA and QCL-TypeD when applicable * UL or, if applicable, joint TCI can also apply to some SRS resources or resource sets for BM   [Mod: the TRS bullet is removed for now per MTK’s concern]  We have concern for proposal 1.5 that additional PL-RS would lead to beam mismatch. So if we want to go with proposal 1.5, we suggest we add a sub-bullet as follows.  **Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#104b-e, further discuss and select between the following two alternatives for path-loss measurement (note: the text below is based on the agreed description in RAN1#104-e):   * Alt1. PL-RS can be included in UL TCI state or (if applicable) joint TCI state.   + FFS: Whether it is always included or not. If not included, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state. * Alt2. PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state   + FFS: Exact association mechanism   + FFS: Whether it is always associated or not. If not associated, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state * If the downlink spatial filter based on indication of QCL-TypeD of PL-RS is not the same as the uplink spatial filter based on indication of unified TCI, it is up to UE whether to derive pathloss based on PL-RS or DL RS provided in the unified TCI |
| OPPO | Proposal 1.1: support. But not sure we need this proposal.  [Mod: It is now a conclusion]  Proposal 1.2: We think we need to first clarify that supporting joint or separate TCI is UE capability. From our perspective, no matter which Alt of switching scheme is adopted, supporting joint or separate TCI is always UE capability. So the UE capability shall be placed in main bullet, instead of only in Alt1. Suggest to update Proposal 1.2 as follows:  **Proposal 1.2**: Supporting joint DL/UL TCI and/or separate DL/UL TCI is UE capability and On Rel.17 unified TCI framework, in RAN1#104b-e, further discuss and select between the following two alternatives for switching between joint and separate DL/UL TCI (note: the text below is based on the agreed description in RAN1#104-e):   * Alt1. A UE can be dynamically indicated with either joint DL/UL TCI or separate DL/UL TCI   + Details on dynamic indication are FFS   + ~~FFS: UE capability for the support of joint DL/UL TCI and/or separate DL/UL TCI~~ * Alt3. A UE can be configured with either joint DL/UL TCI or separate DL/UL TCI via MAC CE signaling   + Details on how this is signaled in relation to TCI activation are FFS   [Mod: Some companies may disagree with this, but let’s see if it is acceptable now. Added]  Proposal 1.3: support in principle. For CSI-RS resource for BM, we would like to make it clear that one CSI-RS resource set with repetition = “On” is included. Suggest to update Proposal 1.3 as follows  **Proposal 1.3**: On Rel.17 unified TCI framework,   * DL or, if applicable, joint TCI can also apply to the following signals:   + CSI-RS resources for CSI   + Some CSI-RS resources for BM, including one CSI-RS resource set with repetition “ON ” ~~if so, which ones (e.g. aperiodic, repetition ‘ON’)~~   + CSI-RS for tracking * UL or, if applicable, joint TCI can also apply to some SRS resources or resource sets for BM   Proposal 1.4: we are not ok to associate the (P0, alpha, closed loop index) with TCI state **for SRS**. Such association shall only be applied to PUSCH and PUCCH. Suggest to update Proposal 1.4 as follows:  **Proposal 1.4**: 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) is also associated with UL or (if applicable) joint TCI state for PUSCH and PUCCH.   * Note: It has been agreed that the setting of (P0, alpha, closed loop index) is associated with UL channel or UL RS   Proposal 1.5: support. |
| MediaTek | **Proposal 1.2**: We think Alt1 and Alt3 are not mutually exclusive since whether DCI can dynamically indicate joint or separate DL/UL TCI could depend on how MAC-CE maps the TCI states to the TCI codepoints. Even Alt1 is supported, MAC-CE still can configure joint TCI only (or separate TCI only). This is similar to Rel-16 S-DCI MTRP, if no TCI codepoint is associated with two TCI states, UE will be scheduled by single TRP only.  [Mod: I tend to agree. Let’s discuss further]  **Proposal 1.3:** We have concern on applying joint/separate TCI to TRS. In Rel-15/16, DL QCL information is semi-statically provided to TRS, which means UE doesn't have to dynamically change UE beam when performs tracking on TRS. However, if joint/separate TCI applying to TRS is allowed, it would be challenging from UE implementation perspective since joint/separate TCI can be updated by DCI signaling.  [Mod: Removed for now] |
| Mod | Addressed comments from Apple, OPPO, and MTK |
| Xiaomi | Added our views above.  Proposal 1.1, support  For Proposal 1.2, we share same view as MTK  Proposal 1.3, support |
| NTT Docomo | Issue 1.6: We believe it is more important to define default PL-RS assumption if PL-RS is not configured. Then, selection between Alt.1 and Alt.2 is not a big problem. Thus, we propose to update as following:  **Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#104b-e, further discuss and select between the following two alternatives for path-loss measurement (note: the text below is based on the agreed description in RAN1#104-e):   * Alt1. PL-RS can be included in UL TCI state or (if applicable) joint TCI state.   + ~~FFS: Whether it is always included or not.~~ If not included, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state. * Alt2. PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state   + FFS: Exact association mechanism   + ~~FFS: Whether it is always associated or not.~~ If not associated, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state   [Mod: Agreed, included]  For Proposal 1.3, if unified TCI is applied to TRS, we have concern on it. Since QCL source RS of unified TCI would be TRS, we don’t understand how it works. (We see TRS is already deleted, but we’d like to have comment) |
| Convida Wireless | Proposal 1.2: OK with the proposal and share the view of MediaTek.  [Mod: changed ‘select’ to down select or combine]  Proposal 1.3: Support. |
| Fraunhofer IIS/HHI | Updated our views in the table.  Conclusion 1.1: Support  Proposal 1.4: Support  Proposal 1.5: Agree in principle. Clarification is required in the bullet added by Apple: does it mean that the QCL-typeD RS of the PL RS and the RS used for spatial relation for an UL transmission must be the same for the UE to apply them? What would be the case if the PL RS is a DL RS and the spatial relation is an UL RS? |
| Apple | Response to Fraunhofer: usually gNB should not provide a standalone UL RS for beam indication. It should provide a DL RS for beam indication for the UL RS for further UE beam tracking. The gNB should try its best to make sure the beam is aligned – the two DL RS: PL-RS and DL RS for direct or indirect beam indication should not lead to beam mismatch. |
| ZTE | Regarding Conclusion 1.1: It is not our preference, but we can live with this conclusion for progress.  Regarding Proposal 1.2, we still think that Alt2A/2B is needed for backward compatibility. Meanwhile, we sympathize with MTK that those alternatives are relevant to different levels, and instead of down-selection, we need to discuss: 1) whether/how to achieve the dynamic indication for joint and separate TCI state; 2) how to support backward compatibility of old gNB/UE.  [Mod: The current narrowing down to Alt1 and Alt3 is based on majority views. Regarding backward compatibility, since this is only for Rel-17 unified TCI, there is no switching with Rel-15/16 – so it doesn’t seem to be an issue.]  Regarding Proposal 1.3, the CSI-RS for BM and CSI should be aperiodic, and we need to consider both CSI-RS for BM with repetition = on/off, rather than repetition =‘on’ only.  [Mod: This can be kept FFS for now - added]  Regarding Proposal 1.4, we support it. It seems that the same mechanism can apply to SRS also. Or, do we miss anything?  [Mod: Please check OPPO’s comment – not OK for SRS]  Regarding Proposal 1.5, NTT DOCOMO’s suggestion seems to be a good way-forward solution. If so, we wonder that the last bullet from Apple can be removed in such case?  [Mod: Replaced by Apple’s last comment] |
| Intel | Updated our views in the table.  **Proposal 1.2:** As discussed in our paper, we do not these two alternatives are mutually exclusive. We are mixing TCI applicability and indication. A MAC-CE can configure what is the type of TCI state i.e., DL/UL/joint for each TCI codepoint. The DCI based indication can then point to any of the 8 codepoints and still satisfy Alt.1 Therefore we prefer to have both alternatives and no down-selection is necessary. For purpose of MAC-CE configuration, the Rel-16 MAC-CE used for mTRP can be re-used and the reserve bits in the MAC-CE can be used for configuring the applicability of the TCI states  [Mod: Revised to include possibility for down-selection or combining – will finalize this meeting]  **Proposal 1.4:** By saying that for PUCCH, the power control parameters are “associated” with the TCI state, we are now introducing new behavior different from spatial relation info framework for PUCCH. For PUSCH and SRS, we are ok but we do not see the need for new behavior for PUCCH. In Rel-16, the PL-RS and power control parameters for PUCCH are include IN the spatialRelationInfo and such behavior should be maintained unless compelling arguments can be provided otherwise  [Mod: I am not sure what your suggestion is. saCould you please suggest an alternative text? Or is it simply that we remove PUCCH?]  **Proposal 1.5:** Similar comment for PUCCH. The PL-RS is currently included in the pucch-spatialRelationInfo. For SRS and PUSCH, MAC-CE is available for configuration, therefore, we believe Alt.1 should be considered for PUCCH and may not be necessary for SRS/PUSCH. Additionally, for bullet added by Apple, while I see the intention, it’s still not clear to us what happens when there is a beam mismatch. If the UE autonomously selects the PL-RS, how does that guarantee same understanding with gNB? |
| Qualcomm | For Proposal 1.2, we are fine for it.  For Proposal 1.3, suggest to add the following two FFSs  **Proposal 1.3**: On Rel.17 unified TCI framework,   * DL or, if applicable, joint TCI can also apply to the following signals:   + CSI-RS resources for CSI   + Some CSI-RS resources for BM, including one CSI-RS resource set with repetition ‘ON’   + FFS: Whether legacy TCI state should be applied to the DL signals not allowed for separate DL or joint TCI state. * UL or, if applicable, joint TCI can also apply to some SRS resources or resource sets for BM   + FFS: Whether legacy spatial relation state should be applied to the UL signals not allowed for separate UL or joint TCI state.   For Proposal 1.4, we are fine for it. For SRS, it would be per SRS set as in R15/16.  For Proposal 1.5, suggest to modify the last note as below or leave it as FFS, since if PL RS is indicated, UE shall use it even if its Rx beam is different from UL Tx beam. To our understanding, this is the R15/16 behavior.   * If the downlink spatial filter based on indication of QCL Type-D of PL-RS is not the same as the UL spatial filter based on indication of Rel-17 unified TCI, it is up to the UE whether to derive path-loss based on PL-RS ~~or DL RS provided in the unified TCI~~   [Mod: Please check latest comment from Apple] |
| Apple | Proposal 1.5:  Response to ZTE, Intel and Qualcomm:If the group has concern for the last bullet, we suggest we go with Docomo’s suggestion to define the default PL-RS and add a new bullet as follows:   * Support of PL-RS associated with or in UL TCI state or (if applicable) joint TCI state is an optional feature |
| vivo | For Conclusion 1.1: This is related to CA discussion. When an RS is shared across CCs, our preference is to use SSB as the source. It is also one of the options listed there.  [Mod: I tend to agree with you. CA issue has been mentioned as one advantage of having SSB as Type-D source RS. But still many companies have issues with it. So this conclusion simply captures the outcome, i.e. no consensus to add more source RS types.]  For Proposal 1.2, we are basically fine.  For Proposal 1.3, we would like to update as following:  **Proposal 1.3**: On Rel.17 unified TCI framework,   * DL or, if applicable, joint TCI can also apply to the following signals:   + CSI-RS resources for CSI   + FFS: Some CSI-RS resources for BM, including one CSI-RS resource set with repetition ‘ON’ * UL or, if applicable, joint TCI can also apply to some SRS resources or resource sets for BM   [Mod: The setting is left FFS for now, but majority of companies support the signals]  For proposal 1.4, we would like to further study. Since this would mean different channels sharing the same P0/alpha configuration.  [Mod: Please check the latest version – separated for different channels. Note that it has been agreed that the setting of those parameters is channel- and signal-specific. So different channels do not share the same configuration]  For proposal 1.5, we are supportive of what DCM and Apple added.  **Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#104b-e, further discuss and select between the following two alternatives for path-loss measurement (note: the text below is based on the agreed description in RAN1#104-e):   * Alt1. PL-RS can be included in UL TCI state or (if applicable) joint TCI state.   + If not included, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state. * Alt2. PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state   + FFS: Exact association mechanism   + If not associated, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state * If the downlink spatial filter based on indication of QCL Type-D of PL-RS is not the same as the UL spatial filter based on indication of Rel-17 unified TCI, it is up to the UE whether to derive path-loss based on PL-RS or DL RS provided in the unified TCI   [Mod: Agreed, please check the latest version] |
| Huawei, HiSilicon | We added our views to some of the listed issues.  Proposal 1.1: The target channel/signal should be listed in the proposal to avoid overkill. On the 1st sub-bullet, we would like to point out that the previous agreement is self-conflicting on whether CSI-RS for CSI can be used for TypeD QCL indication for PDCCH/PDSCH (main bullets says yes, while the note says no), and we suggest clarifying the understanding on this.  [Mod: Target channels (per previous agreement re Rel-17 unified TCI are added)  **Agreement**  On Rel.17 unified TCI framework, the supported source/target QCL relations in the current TS38.214 V16.4.0 is supported for QCL Type D.   * Note: This implies that the following source RS types for DL QCL (Type D, for DL RX spatial filter reference) information for DL UE-dedicated reception on PDSCH and all/subset of CORESETs are supported:   + CSI-RS for beam management   + CSI-RS for tracking * FFS (to be decided by RAN1#104bis-e): If SSB, CSI-RS for CSI, and/or SRS for BM are also supported as source RS types   Excerpt from TS38.214 V16.4.0  For the DM-RS of PDCCH, the UE shall expect that a *TCI-State* indicates one of the following quasi co-location type(s):  - 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with the same CSI-RS resource, or  - 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*, or  - 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured without higher layer parameter trs-Info and without higher layer parameter *repetition* and,when applicable, 'typeD' with the same CSI-RS resource.  For the DM-RS of PDSCH, the UE shall expect that a *TCI-State* indicates one of the following quasi co-location type(s):  - 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with the same CSI-RS resource*,* or  - 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*,or  - typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured without higher layer parameter *trs-Info* and without higher layer parameter *repetition* and, when applicable, 'typeD' with the same CSI-RS resource.  Proposal 1.2: We got a question on whether the so-called dynamic indication is among the MAC-CE activated TCI states or not, and if yes, we suggest making this clear in Alt-1.  [Mod: The proponents can perhaps clarify. But I think this is a part of the discussion which will take place after this proposal is agreed – observe that the proposal includes the need for further discussion and decision in this meeting]  Proposal 1.3: We are still concerned on this proposal. Our understanding is the joint, DL, and UL TCI in R17 are mainly for data channels (or reference signals that are tightly related to data channels), and we failed to understand why they should be applied to reference signals for other purposes.  There can be multiple configured CSI-RS resources for CSI, which one of them should follow the indicated DL or joint TCI? What happens to the TCI state indicated to this CSI-RS resource using R16 mechanism?  What is the meaning of ‘some’ here? Why joint/DL TCI should be applied to CSI-RS resource set configured with repetition ‘ON’, where the UE is expected to train its Rx beam? Why joint/UL TCI should be applied to SRS resources for BM, and which of them are ‘some’?  Some further thoughts: For P/SP CSI-RS, its TCI state is configured/activated by RRC/MAC-CE, and it is unclear why/how it should now follow the active PDCCH/PDSCH reception. For AP CSI-RS for CSI, when the scheduling offset is smaller than certain threshold, its QCL will follow PDCCH as in R16, with which there is no need to make a change.  [Mod: Please check latest version]  Proposal 1.4: It would be better if there can be some description or example on how such association is to be conveyed to UE.  [Mod: This level of details is perhaps more relevant for RAN2. Association means some linkage with, but not included in the TCI. How this is done is up to RAN2]  Proposal 1.5: On the last bullet, instead of saying ‘up to UE’, we would suggest picking one out of the two different indicated RS resource(s).  [Mod: “Up to UE” is not there anymore] |
| Mod | Revised proposals to address comments |
| AT&T | Added more views to more items above.  For proposal 1.2, share same view as Intel as these are not necessarily mutually exclusive, and the downselectjon should be a possibility.  For proposals 1.3-1.5 we are ok in principle. |
| Samsung | Thank you for the proposals.  For conclusion 1.1: Conclusion 1.1 is not our preference, we see a benefit in supporting SSB and SRS for BM as source RS types for DL QCL Type D. But we understand that the number of proponents and opponents are almost the same and an offline discussion has been done.  Proposal 1.2: Regarding the statement about UE capability, this should be FFS:  FFS: The support for joint DL/UL TCI and/or separate DL/UL TCI is subject to UE capability.  We have not discussed whether all UEs should support joint or separate TCI states or if this is based on UE capability more discussion is needed.  For this proposal, we prefer Alt3.  Proposal 1.3: We would like to understand the “FFS” in the sub-bullets of CSI-RS for CSI and CSI-RS for BM. This implies that the Rel-17 TCI state would not apply to all CSI-RS for CSI or all CSI-RS for BM pending the outcome of that FFS.  Proposal 1.4: We are not supportive of this proposal. We would like to see a unified design for all uplink channels and signals. This would save configuration overhead. It seems that there is some correlation between proposal 1.4 and proposal 1.5, the former is for the PC parameters, while the latter is for the PL RS, we would like to understand the rationale for agreeing to have the PC parameters associated (rather than included) with the TCI state in this proposal but discussing association vs inclusion in proposal 1.5.  Proposal 1.5: While our preference is Alt4 from RAN1#104-e, we will accept the view of the majority and discuss down selection between Alt1 and Alt2. However, the last bullet seems to be confusing what is the meaning of having this proposal as optional:   * UE doesn’t support PL-RS measurements? This is not possible. * PL-RS is based on Rel-16 behavior, this would complicate the design especially from a network perspective, if the network has only Rel-17 UEs, it would be required to support the legacy PL-RS behavior as well as one of the two alternatives listed in this proposal. In this case, wouldn’t it be better to just keep the legacy PL-RS behavior for all UEs. |
| ZTE | Regarding Conclusion 1.1: We can live with updated conclusion. After reviewing the views from other companies and existing QCL chain for CSI-RS for CSI, we are wondering whether we can have a second chance for supporting CSI-RS for CSI. Maybe, opponents can clarify why this CSI-RS for CSI should be precluded as QCL source RS in technical, considering that it has been supported in Rel-15/16.  Regarding Proposal 1.2: Thanks so much for the Moderator’s efforts. We are fine to further discuss the two majority-supported alternatives first of all. But, after reviewing these two alternatives, there may be serious backward compatibility issues herein.   * Specifically, for Alt1, how/whether the UE can realize that this DCI fields further contains the separate DL/UL TCI, rather than Rel15/16 DCI format; * For Alt3, how/whether the Rel-15/16 MAC-CE for PDSCH corresponding to DCI format 1-1/2 or the newly introduced MAC-CE can be used from UE perspective. * Also, joint DL/UL TCI and/or sepetate DL/UL TCI may be up to UE capability.   Therefore, we suggest to add the following FFS in the proposal-1.2  FFS: Functionality/mode corresponding to either joint DL/UL TCI, separate DL/UL TCI, or dynamically switching between joint and separate is enabled by RRC  Regarding Proposal 1.3: From gNB vendors, the periodic/semi-persistent CSI-RS may be the source of joint TCI state, and it would be very wired that QCL assumption corresponding to the periodic/semi-persistent DL RS is updated by dynamic signaling or that the QCL chain becomes a closed loop. Therefore, if we try to move forward this proposal, we suggest to restrict that the CSI-RS for CSI cand CSI-RS for BM is aperiodic only as first step, rather than a general description that implies all types of time-domain behavior are supported.  **Proposal 1.3**: On Rel.17 unified TCI framework,   * DL or, if applicable, joint TCI can also apply to the following signals with aperiodic only:   + CSI-RS resources for CSI     - FFS: Supported settings, e.g. ~~aperiodic-only,~~ some vs all CSI-RS resources for CSI   + Some CSI-RS resources for BM     - FFS: Supported settings, e.g. one CSI-RS resource set with repetition ‘ON’, or repetition of both ‘ON’ and ’OFF’~~, aperiodic-only~~   + FFS: Whether legacy TCI state should be applied to the DL signals not allowed for separate DL or joint TCI state. * UL or, if applicable, joint TCI can also apply to some SRS resources or resource sets for BM   + FFS: Whether legacy spatial relation state should be applied to the UL signals not allowed for separate UL or joint TCI state   Regarding Proposal 1.4/1.5: We support both of them.  If some companies has concerns about association or inclusion, how about we describe this two alternative using a general way, like ‘included or associated with’ , and then we can have a note that this final decision is up to RAN2 signaling design. If so, the two alternatives in proposal 1.5 can be merged, and the following note can be added for both proposal 1.4/1.5.   * + Note: either ‘be included in’ or ‘be associated with (but not included in)’ are up to RAN2 decision. |
| Spreadtrum | Conclusion 1.1: Support.  Proposal 1.2: Support. In our views, the switching between joint TCI and separate TCI is mainly for UL TCI state update, which is similar as UL TCI state indication in either joint or separate TCI scheme. Therefore, DCI based switching should be applicable.  Proposal 1.4: Support.  Proposal 1.5: Support. |
| MediaTek | Proposal 1.3: In precious meeting, RAN1 agreed that joint/separate TCI can optionally apply to SRS for CSI in “resource set” level. For CSI-RS for CSI, joint/separate TCI should apply in “resource set” level as well. For CSI-RS/SRS for BM, since the use case would be gNB or UE beam refinement for an indicated TCI state, we don't see the need to support it in “resource” level. Note that if “resource” level is supported, UE has to support the beam measurements on a set of RSs based on legacy TCI/spatial relation and Rel-17 joint/separate TCI at the same time, where Rel-17 joint/separate TCI may be dynamically updated by DCI.  Proposal 1.4: Regarding the association mechanism, we think it has to be discussed later, similar to Alt2 in Proposal 1.5. Furthermore, we see if Alt2 is supported, the association mechanism should be unified for PC parameters and PL-RS. Therefore, we would like to add an FFS bullet under this proposal:   * FFS: Exact association mechanism and whether to support a unified mechanism for the setting of (P0, alpha, closed loop index) and PL-RS, if PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state.   Proposal 1.5: Regarding the last bullet in this proposal, we are curious whether it is needed since any Rel-17 feature shall be optional anyway. However, we are fine with it if it can address concern from companies. |
| LG | Our view is updated in the table.  Conclusion 1.1: Support  Proposal 1.2; We still think that the switching between joint TCI and UL TCI would not happen so frequently, so our first preference is RRC based switching. Considering many companies’ support on dynamic switching, we can compromise to accept MAC-CE based switching but not DCI, which is obviously an over-design. We can directly agree on MAC-CE based switching as a compromise between the two parties (DCI vs RRC).  Proposal 1.3: OK  Proposal 1.4 and 1.5: Direction is good as direct or indirect linkage is necessary from technical perspective. While the association of the PC parameters with TCI state (Alt2) is not much different compared to Alt1 from the functionality point of view, it may cause lots of variants on how to provide the association as many companies mentioned. Also, as shown in the current version of proposal, the way of association is unclear and it can be different for each channel/signal, e.g. PUSCH/PUCCH/SRS. Hence, the PC parameter included in TCI state seems still simpler and straight-forward by taking PL RS in Proposal 1.5 into account together. |

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

Table 4 Summary: issue 2

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1 | Support CSI-RS associated with/configured for non-serving cell(s) as a measurement RS  Note: Supporting this implies the support of Rel-15 CSI-RSRP as beam metric/reporting | CSI-RS for mobility/RRM associated with NSC:   * **Yes (6)**: Huawei, HiSi, ZTE, CATT, Sony, LGE * **No (7)**: Samsung, Nokia/NSB, OPPO, MTK, Xiaomi, Qualcomm   CSI-RS for BM configured for NSC:   * **Yes (8)**: Ericsson, Nokia/NSB, APT/FGI, Futurewei, Huawei, HiSi * **No (4)**: Samsung, OPPO, MTK, Xiaomi,   CSI-RS for tracking (TRS) configured for NSC:   * **Yes (4)**: Nokia/NSB, IDC (add PCI in TRS), Futurewei * **No (5)**: OPPO, MTK, Xiaomi, Huawei, HiSi |
| 2.2 | Whether the measurement for SS-RSRP is limited within SMTC | **Yes (2)**: vivo (follow L3-RSRP), ZTE (first priority)  **No (4)**: CATT, MTK, Huawei, HiSi,  **Depends on RAN2/RAN4 response on whether inter-frequency is supported (1)**: Apple |
| 2.3 | Maximum value of K (beams associated at least with non-serving cell(s) reported in a single CSI reporting instance) | **1**:  **>1 (specify)**: Ericsson (up to 8, UE capability), Nokia/NSB (4), MTK (4), Intel (UE capability), Samsung (UE capability), APT/FGI (up to 8, UE capability), Sony, ZTE, Qualcomm, Xiaomi, NTT Docomo (UE capability), CATT, Huawei, HiSi (up to 16, UE capability), Spreadtrum, LG |
| 2.4 | If max K>1, how to set the value of K  Alt1: RRC configured (based on UE capability)  Alt2: Dynamically selected by NW via MAC CE  Alt3: Dynamically selected by NW via DCI  Alt4: Dynamically selected by UE (indicated in CSI reporting) | **Alt1**: Apple, MTK, APT/FGI, ZTE, Qualcomm, NTT Docomo, CATT, Huawei. HiSi, Spreadtrum  **Alt2**:  **Alt3**:  **Alt4**: Samsung, Sony |
| 2.5 | Can beam reporting associated with non-serving cell(s) be mixed with that with serving-cell in one reporting instance? | **Yes (16)**: vivo, Ericsson, Samsung, Nokia/NSB, Spreadtrum, CATT, Intel, LGE, Apple, MTK, APT/FGI, Sony, ZTE (Up to config.), Futurewei, Xiaomi, NTT Docomo, Huawei. HiSi (up to configuration)  **No (1)**: ASUSTeK |
| 2.6 | The maximum value of N1 (number of non-serving cell(s) RRC configured for measurement/reporting) | **1**: OPPO, Nokia/NSB, Spreadtrum  **>1 (specify)**: Samsung (UE capability), Sony, ZTE, Qualcomm (UE capability), NTT Docomo (at least 3 or more), CATT (UE capability), Xiaomi, Huawei. HiSi (UE capability) |
| 2.7 | The maximum value of N2 (number of non-serving cell(s) in a single CSI reporting instance comprising K beams) | **1**: OPPO, Spreadtrum, Nokia/NSB  **≤ N1**: NTT Docomo, CATT (UE capability), Xiaomi (3), Samsung, Sony, ZTE, Qualcomm, Huawei. HiSi (UE capability) |
| 2.8 | Supported DL QCL Type-D and/or UL TX spatial reference source RS type(s) for L1/L2-centric inter-cell mobility by extending Rel-17 unified TCI framework to inter-cell indication | DL QCL Type-D:   * CSI-RS for BM configured for NSC: Sony, Nokia/NSB, ZTE, Lenovo/MoM, Futurewei * CSI-RS for tracking configured for NSC: NTT Docomo, , Sony, Nokia/NSB, ZTE, Lenovo/MoM, Futurewei * CSI-RS for mobility associated with NSC: Sony, ZTE, LG * SSB associated with NSC as direct QCL source: Samsung, NTT Docomo, MTK, ZTE, Qualcomm, Lenovo/MoM, Xiaomi * SSB associated with NSC as indirect QCL source: Sony * SRS for BM configured for NSC: Nokia/NSB * Other: Apple (based on legacy QCL rule), APT/FGI (at least support legacy QCL rule), LG (based on *MeasObjectId*)   UL TX spatial reference:   * CSI-RS for BM configured for NSC: Sony, ZTE, Futurewei * CSI-RS for tracking configured for NSC: Sony, ZTE, Futurewei * CSI-RS for mobility associated with NSC: Sony, ZTE * SSB associated with NSC as direct QCL source: Samsung, NTT Docomo, MTK, Sony, ZTE, Qualcomm, Lenovo/MoM, Xiaomi * SSB associated with NSC as indirect QCL source: * SRS for BM configured for NSC: * Other: Apple (based on legacy rule), APT/FGI (at least support legacy QCL rule)   Clarify whether to support changing serving cell and whether to support CSI-RS based measurement before deciding source RS type(s) of DL QCL Type-D and/or UL TX spatial reference: Huawei, HiSi |
| 2.9 | Support for event-triggered (UE-initiated) inter-cell SS-RSRP reporting | **Yes (14)**: Huawei, HiSi, Qualcomm, Sony, Apple, Samsung, Xiaomi, ASUSTeK, IDC (inter-cell BFR), ZTE, Lenovo/MoM, Futurewei, CATT  **No**: |
| 2.10 | Timing assumption (e.g. time of arrival and time of the measurement) for measurement of non-serving cell measurement RS | TA/TAG of SC and configured NSC(s) shall be the **same**: Xiaomi  TA/TAG of SC and configured NSC(s) can be **different**: vivo (UE can report), Intel, Apple (with PDCCH ordered NSC PRACH, no TAG), Qualcomm, CATT (TA difference is configured), APT/FGI, Sony, ZTE, Futurewei, Huawei, HiSi, LG |

The following observation can be made:

* (2.3) There seems to be consensus in supporting Kmax>1 and that it is a UE capability. Some values such as 4 and 8 are proposed.
* (2.5) Strong majority on supporting beam reporting associated with non-serving cell(s) mixed with that with serving-cell in one reporting instance (to avoid using multiple reports which result in additional latency and mismatch in report qualities)
* (2.9) There seems to be consensus in supporting event-triggered/UE-initiated reporting
* (2.10) There seems to be consensus in supporting different TA/TAG of SC and configured NSC(s)

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

**Proposal 2.1**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,

* On the value of K (defined in RAN1#104-e as the number of beam qualities associated at least with non-serving cell(s) can be reported in a single CSI reporting instance), the maximum value of K is a UE capability and does not exceed [4, 8, 16]
* Support MAC CE based dynamic activation/deactivation for L1-RSRP measurement corresponding to a non-serving cell measurement RS
* In one reporting instance, depending on NW configuration, beam(s) associated with non-serving cell(s) can be mixed with that associated with serving-cell
  + FFS: How to report the K beams and corresponding qualities if the Tx power among the non-serving cell(s) and with serving-cell is not the same
* In addition to NW-triggered measurement/reporting, event-based (UE-initiated) measurement/reporting is supported
  + FFS: Definition of triggering event
  + Treated with lower priority
* Timing assumption for DL measurement associated with the serving cell and non-serving cell(s) can be the same or different
  + FFS: If timing assumption comprises TA, TAG, or both
  + FFS: Details of TA measurement and configuration, e.g. PDCCH ordered non-serving cell PRACH for TA measurement

Table 5 Additional inputs: issue 2

|  |  |
| --- | --- |
| **Company** | **Input** |
| Apple | For measurement, we think the UE complexity and flexibility to support multiple-cell L1 measurement could be one issue. So we suggest we consider the following proposals:  ***Support MAC CE based dynamic activation/deactivation for a L1-RSRP measurement corresponding to a non-serving cell RS***  In addition, we suggest we discuss the TA assumption when UE starts to communicate with the non-serving cell, whether UE should assume TA=0 or maintain old TA or NW can provide a new TA after it triggers PDCCH ordered PRACH. |
| APT/FGI | We have provided our views above |
| Nokia/NSB | For issue 2.8, we may not need to define QCL source for UL TCI. RAN1 does not have any agreement whether UE can send UL channel/RS toward non-serving cell(s) |
| Sony | Add and modify our views. |
| ZTE | Our views are provided above. |
| Futurewei | Our views are added. |
| Mod | Moderator proposals have been added |
| Apple2 | We suggest we remove TAG since UE is not required to communicate with both cells simultaneously, and add a FFS on PDCCH ordered non-serving cell PRACH for TA measurement.  **Proposal 2.1**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * On the value of K (defined in RAN1#104-e as the number of beam qualities associated at least with non-serving cell(s) can be reported in a single CSI reporting instance), the maximum value of K is a UE capability and does not exceed [4] * In one reporting instance, depending on NW configuration, beam reporting associated with non-serving cell(s) can be mixed with that associated with serving-cell * Event-based (UE-initiated) measurement/reporting is supported   + FFS: Definition of triggering event * TA~~/TAG~~ associated with the serving cell and non-serving cells can be the same or different   + FFS: PDCCH ordered non-serving cell PRACH for TA measurement |
| OPPO | Regarding Proposal 2.1: do not support different TA/TAG at least for the current moment. We need the LS replies to decide the applicable scenario before we can decide that. Furthermore, we prefer to limit the number of non-serving cell to be one and that cell shall be one of the cells that are reported in RRM measurement reporting.  **Proposal 2.1**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * On the value of K (defined in RAN1#104-e as the number of beam qualities associated at least with non-serving cell~~(s)~~ can be reported in a single CSI reporting instance), the maximum value of K is a UE capability and does not exceed [4] * In one reporting instance, depending on NW configuration, beam reporting associated with non-serving cell~~(s)~~ can be mixed with that associated with serving-cell * Event-based (UE-initiated) measurement/reporting is supported   + FFS: Definition of triggering event * ~~TA/TAG associated with the serving cell and non-serving cells can be the same or different~~ * The number of non-serving cell being measured is up to one and that non-serving cell shall be one of cells reported in L3 RRM measurement report.   [Mod: Since there are at least 7 companies who will disagree with the last proposed bullet, I will not include this in the proposal. Anyway this will be a separate topic not within the scope of this proposal. I will change cells to cell(s) in the TA bullet.] |
| MediaTek | We agree TAs among SC and configured NSC(s) can be different. However, we share the same view with Apple that UE doesn’t have maintain them simultaneously. |
| Mod | Addressed inputs from Apple, OPPO, and MTK |
| Xiaomi | Added our views above.  We prefer to restrict same TA between serving cell and non-serving cell. |
| MediaTek | Regarding the second bullet, we would like to add one FFS to raise the issue if the Tx power among NSC(s) and with SC is not the same.   * FFS: How to report the K beams and corresponding qualities if the Tx power among the non-serving cell(s) and with serving-cell is not the same.   [Mod: Done]  Regarding the 3rd bullet, we would like to clarify whether UE-trigger reporting is an additional mechanism (in additional to CSI report configured/activated/triggered by NW). Or this implies Rel-17 only supports UE-trigger reporting.  [Mod: Yes it is understood as an additional mechanism similar to (P)BFR, not NW-triggered. Please check latest version] |
| ZTE | Regarding 2nd bullet, we suggest to remove ‘reporting’ for sake of presentation.   * In one reporting instance, depending on NW configuration, beam associated with non-serving cell(s) can be mixed with that associated with serving-cell   [Mod: Yes sir ☺]  Regarding 3rd bullet, we think the clarification about whether NW-initialized NSC beam reporting is supported or not is needed. From our perspective, the NW-initialized one should be supported as well.  [Mod: Agreed, please check revised version]  Regarding 4th bullet. Could any opponent clarify why TAG cannot be different since the different TA is tended to be agreed.  [Mod: Added FFS on TAG as a compromise] |
| Intel | We would not want to have specifics in the FFS of the last bullet since we have hardly discussed uplink. There we can have FFS on details. We also do not agree to removing TAG from the bullet.  [Mod: Added FFS on TAG as a compromise]   * TA or TAG configuration associated with the serving cell and non-serving cell(s) can be the same or different   + FFS: Details of TA measurement and configuration |
| Qualcomm | We are generally fine for Proposal 2.1. For the last bullet, we share the same view as ZTE and Intel that it is natural to support different TAGs for different Tas. Suggest to at least add TAG in the bullet.  [Mod: Added FFS on TAG as a compromise] |
| Apple | Response to ZTE, Intel and Qualcomm:  For inter-cell mobility, UE should not communicate with both cells simultaneously, so we should not consider different value of TA as different TAG.  [Mod: Added FFS on TAG as a compromise]  Regarding the suggestion from Intel to make it general, we have already agreed to study TA in the first R17 meeting, we should make some progress to list some specific study point. |
| Vivo | This is mainly for measurement and reporting. Thus would like to clarify as following.   * Timing assumption for DL measurement associated with the serving cell and non-serving cell(s) can be the same or different   [Mod: Good point]  We would also like to add the following bullet, as commented by Apple.   * Support MAC CE based dynamic activation/deactivation for a L1-RSRP measurement corresponding to a non-serving cell RS   [Mod: I can add in brackets and see if companies have concern]  For event based report, we are also interested in this, but a little bit concerned on treating directly without clear understanding on how the baseline measurement and reporting is working.   * Event-based (UE-initiated) measurement/reporting is supported   + FFS: Definition of triggering event   + Treated with lower priority.   [Mod: It is reasonable from FL perspective] |
| Huawei, HiSilicon | We added our views to some of the listed issues.  Proposal 2.1: We suggest adding 8 and 16 as candidate maximum number inside the brackets. |
| Mod | Revised proposal to address inputs |
| Samsung | We are fine with this proposal. However, we for the newly added bullet on MAC CE activation/deactivation we would like to understand the rationale behind this. Isn’t RRC configuration sufficient? Maybe we can have FFS in front of this bullet. |
| ZTE | We share the same concerns as Samsung. Does it mean that we need to support semi-persistent CSI measurement/reporting for this case, regarding to ‘NW-triggered measurement/reporting’?  Besides, we are fine with other bullets. |
| Spreadtrum | For event-based (UE-initiated) measurement/reporting, more information is needed before agreeing on this new mechanism. For the newly added bullet on MAC CE activation/deactivation, we suggest it to be FFS. |
| MediaTek | Regarding “NW-triggered measurement/reporting” in the 4th bullet, could we change “NW-triggered” to “NW-initiated” since “NW-triggered” may imply only AP reporting triggered by DCI is supported.  Regarding MAC CE based dynamic activation/deactivation for a L1-RSRP measurement, we prefer to have it since such measurement on non-serving cell may not be always needed. However, current spec already supports dynamic activation/deactivation for SP CSI-RS. Thus, this bullet is only needed for non-serving cell SSB.   * Support MAC CE based dynamic activation/deactivation for L1-RSRP measurement corresponding to a non-serving cell SSB |
| LG | Our view is updated in the table.  On proposal 2.1: For the first bullet, we are not sure yet whether UE capabilty on the value of K is really necessary since the reporting mechanism is still unclrear. If it is a normal beam reporting, the maximum value of K can be fixed as 4 and no UE capability may need to be defined. We prefer to discuss UE capablity after stabilizing the repoting mechanism.  For the last bullet, we need to consider panel-specific transmission aspect as well. In Positioning, UE TEG (timing error group) has been defined so that each TEG needs to manage TA/TAG separately. |

### Issue 3 (beam indication signaling medium)

Table 6 Summary: issue 3

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 3.1 | Support for DCI formats for Rel.17 unified TCI framework beam indication (TCI state update) beyond the agreed DCI formats 1\_1/1\_2 with DL assignment   * Alt0: No additional DCI format is supported * Alt1: DCI formats 1\_1 and 1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI   + Support DCI acknowledgment mechanism, e.g. based on SPS PDSCH release, based on triggered SRS, based on DCI indicating SCell dormancy   + FFS: How to identify DCI formats 1\_1/1\_2 used for beam indication only (not for scheduling a PDSCH reception, not indicating a SPS PDSCH release, or not indicating Scell dormancy), considering impacts on PDCCH coverage and scheduling mechanism   + FFS: Whether the UE can/shall assume the gNB configured application time is after ACK transmission * Alt2: Dedicated DCI format other than 1\_1/1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI * Alt3: UL-related DCI formats 0\_1/0\_2 with UL grant, applicable only for UL-only TCI of separate DL/UL TCI | **Alt0 (4)**: Fujitsu, Ericsson, Huawei, HiSi, Spreadtrum(2nd preference)  **Alt1 (18)**: Nokia/NSB, NTT Docomo, Verizon, KDDI, Samsung (2nd preference), OPPO, Spreadtrum, CATT, ZTE, MTK, APT/FGI, Intel, Apple, Qualcomm, Sony, Convida, , AT&T  **Alt2 (7)**: Samsung (1st preference), OPPO (DCI Format 1\_0), Intel, APT/FGI, Futurewei, CATT  **Alt3 (9)**: IDC, Lenovo/MoM, MTK, Xiaomi, Intel, Sony, LGE, NEC. |
| 3.2 | If Alt1/Alt2 is supported, DCI acknowledgment mechanism (including supported codebooks and timing relationship) | **Mechanism analogous to Rel-15/16 SPS PDSCH release** (both Rel-15/16 type-1 and type-2 codebooks): ZTE, MTK, APT/FGI, Apple, Samsung, Qualcomm, OPPO, NTT Docomo, CATT, Sony, Nokia/NSB, NEC  **HARQ timing analogous on Rel-15/16 definition** (ACK reported in PUCCH *k* slots after PDCCH reception where *k* is indicated by the PDSCH-to-HARQ\_feedback timing indicator DCI field, else RRC configured): Samsung, ZTE, MTK, APT/FGI, Apple, Qualcomm, OPPO, NTT Docomo, CATT, Sony, Nokia/NSB, NEC |
| 3.3 | If Alt1/Alt2 is supported, mechanism for identifying/differentiating the DCI format used for beam indication only | Combination of DCI fields with set values (differentiating from SPS PDSCH release):   * FDRA: Spreadtrum, MTK, Apple, ZTE, Qualcomm, Samsung, OPPO, APT/FGI, NTT Docomo * MCS: Spreadtrum(1’s), MTK (1’s), Apple, ZTE, Qualcomm, Samsung, OPPO, APT/FGI, Nokia/NSB, NTT Docomo * RV: MTK (1’s), Apple, ZTE, Qualcomm, Samsung, OPPO, APT/FGI, Nokia/NSB, NTT Docomo * NDI: Spreadtrum (0’s), MTK (0’s), Apple, ZTE, Qualcomm, Samsung, OPPO, APT/FGI, Nokia/NSB, NTT Docomo * HPN: APT/FGI   RNTI:   * **CS-RNTI** (following SPS PDSCH release): Spreadtrum, MTK, ZTE, APT/FGI, Apple, Qualcomm, Samsung, NTT Docomo, OPPO, Nokia/NSB, NEC * **Other RNTI**: CATT, Futurewei |
| 3.4 | If Alt1/Alt2 is supported, which DCI fields are needed/used (in addition to TCI field(s))?  Note: As it is customary to do so, the remaining unused DCI fields and codepoints can be utilized for future use | DCI fields:   * Identifier for DCI formats: Samsung, ZTE, MTK, Sony, Qualcomm, NTT Docomo * Carrier indicator: ZTE, MTK, Samsung, Qualcomm, NTT Docomo * Bandwidth part indicator: ZTE, MTK, Samsung, Qualcomm, NTT Docomo * TDRA: ZTE, Samsung, MTK (used for type-1 codebook), Qualcomm, NTT Docomo * DAI (if configured): ZTE, Samsung, MTK, Qualcomm, NTT Docomo * TPC command for scheduled PUCCH: ZTE, Samsung, MTK, Qualcomm, NTT Docomo * PUCCH resource indicator: Samsung, ZTE, Samsung, MTK, Nokia/NSB, Sony, Qualcomm, NTT Docomo * PDSCH-to-HARQ\_feedback timing indicator (if present): Samsung, ZTE, Samsung, MTK, Sony, Qualcomm, NTT Docomo |
| 3.5 | The use of TCI fields for beam indication  Note: This can be dependent on the DCI format | **Joint TCI**: ZTE, MTK, Apple, Qualcomm, OPPO, Samsung, Nokia/NSB, APT/FGI, NTT Docomo, CATT, NEC, Spreadtrum  **Either DL TCI or UL TCI for separate DL/UL TCI**: ZTE, MTK (depends on issue 1.3), Apple, Qualcomm, OPPO, Samsung, Nokia/NSB, APT/FGI, Sony, Futurewei, NTT Docomo, CATT, NEC  **Both DL TCI and UL TCI for separate DL/UL TCI**: Nokia/NSB, Samsung (only if DCI without DLA is supported), MTK (depends on issue 1.3), Sony, Qualcomm, Lenovo/MoM, NTT Docomo, CATT, NEC, Spreadtrum |
| 3.6 | Beam application time (BAT):   * Alt1: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the DCI with the joint or separate DL/UL beam indication * Alt2A: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the acknowledgment of the joint or separate DL/UL beam indication * Alt 2B: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the acknowledgment of the joint or separate DL/UL beam indication, except that the (new) TCI state update can be applied to the PDSCH, if it exists, (scheduled by the beam indication DCI) and corresponding ACK transmission (provided that the time offset between the DCI and the scheduled PDSCH exceed the threshold, analogous to Rel.15/16) * Alt2C: Support both Alt1 and Alt2A, and introduce a UE capability that indicates the support of Alt1 or Alt2A * Alt3: the first slot that is at least X1 ms or Y1 symbols after the [first/last] symbol of the DCI with beam indication and X2 ms or Y2 symbols after the [first/last] symbol of the acknowledgment of the beam indication | **Alt1**: vivo, Ericsson, Samsung (DCI with DLA, 1st pref), Convida, MTK (1st preference), Xiaomi, Spreadtrum  **Alt2A**: IDC, Fujitsu, Lenovo/MoM, NTT Docomo, Huawei, HiSi, OPPO (Alt2A+ meet the UE capability which the minimum time between the DCI and the beam switch time), CATT, ZTE, APT/FGI, Intel, Apple, Qualcomm, Sony, Samsung (DCI without DLA)  **Alt2B**: Nokia/NSB, NTT Docomo, Xiaomi, LGE, NEC, Samsung (DCI with DLA, 2nd pref)  **Alt2C**: MTK (2nd preference)  **Alt3**: OPPO, Spreadtrum |
| 3.7 | Support for group-based DCI in Rel.17 unified TCI framework | **Yes:** Intel, Qualcomm, NTT Docomo  **No:** IDC, Apple, Huawei, HiSi |
| 3.8 | Support for DCI ACK/NAK for DCI formats 1\_1/1\_2 with DL assignment when used for beam indication | **Yes:** CATT, Apple, Samsung, NEC  **No:** |

The following observation can be made:

* (3.1-3.5) Strong majority in supporting DCI formats 1\_1/1\_2 without DL assignment (a number of companies supporting other alternatives are also supportive of this) as described in the last meeting.
  + Main reasons mentioned: 1) Lower beam application latency due to more efficient ACK especially for PDSCH, 2) Better accommodate separate DL/UL TCI and, if agreed, M/N>1, 3) Reserved DCI fields can be used for future purposes (future proof)
  + In addition, a number of supporting companies provide more details for the components (e.g. how to differentiate beam indication from other usages, ACK mechanism following SPS PDSCH release, DCI fields)
  + The use of this format for signaling joint TCI, DL TCI (for separate DL/UL TCI), and UL TCI (for separate DL/UL TCI) seems clearly supported. Whether to signal both DL and UL TCIs for separate DL/UL TCI can be further discussed.

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

**Proposal 3.1**: For beam indication with Rel-17 unified TCI, ...

For beam indication with Rel-17 unified TCI, support DCI format 1\_1/1\_2 without DL assignment:

* Use ACK/NACK mechanism analogous to that for SPS PDSCH release with both type-1 and type-2 HARQ-ACK codebook:
  + Upon a successful reception of the beam indication DCI, the UE reports an ACK
    - Note that upon a failed reception of the beam indication DCI, a NACK can be reported.
    - For type-1 HARQ-ACK codebook, a location for the ACK information in the HARQ-ACK codebook is determined based on a virtual PDSCH indicated by the TDRA field in the beam indication DCI, based on the time domain allocation list configured for PDSCH
    - For type-2 HARQ-ACK codebook, a location for the ACK information in the HARQ-ACK codebook is determined according to the same rule for SPS release
  + The ACK is reported in a PUCCH *k* slots after the end of the PDCCH reception where *k* is indicated by the PDSCH-to-HARQ\_feedback timing indicator field in the DCI format, or provided *dl-DataToUL-ACK* or *dl-DataToUL-ACK-ForDCI-Format1-2-r16* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the DCI
* When used for beam indication:
  + CS-RNTI is used to scramble the CRC for the DCI
  + The values of the following DCI fields are set as follows:
    - RV = all ‘1’s
    - MCS = all ‘1’s
    - NDI = 0
    - Set to all ‘0’s for FDRA Type 0, or all ‘1’s for FDRA Type 1, or all ‘0’s for dynamicSwitch (same as in Table 10.2-4 of TS38.213)
    - FFS: Whether HPN is also used
* Use at least the existing TCI field (always present) to signal the following: 1) Joint DL/UL TCI state, 2) DL TCI state, and/or 3) UL TCI state
  + FFS: Whether both DL TCI and UL TCI states can be signaled in one instance of beam indication DCI
* In addition, use (at least) the following DCI fields:
  + Identifier for DCI formats
  + Carrier indicator
  + Bandwidth part indicator
  + TDRA
  + Downlink assignment index (if configured)
  + TPC command for scheduled PUCCH
  + PUCCH resource indicator
  + PDSCH-to-HARQ\_feedback timing indicator (if present)
* The remaining unused DCI fields and codepoints are reserved

Table 7 Additional inputs: issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| MediaTek | Update views from MediaTek.  On issue 3.5, we think this can be discussed after issue 1.3 is concluded. |
| APT/FIG | Regarding 3.5, our views are missed and added back (i.e., set values for HPN field). |
| CMCC | Update our views on issue 3.1. |
| Nokia/NSB | Updated with Nokia’s view  For Issue 3.5, we may need to decide whether only one TCI state can be associated to each codeword of TCI field, or codeword of TCI field can be associated to both of separated DL/UL TCI state |
| Sony | Our more view added. |
| ZTE | Our views are provided above. |
| Futurewei | Our views are added and updated |
| Mod | Moderator proposals have been added |
| Apple2 | As we have proposed in our contribution, for the highlighted part, we suggest the following:   * ***For Type-1 HARQ-ACK codebook, a location for the ACK information in the HARQ-ACK codebook is determined based on a virtual PDSCH indicated by the TDRA field in the beam indication DCI, based on the time domain allocation list configured for PDSCH*** * ***For Type-2 HARQ-ACK codebook, a location for the ACK information in the HARQ-ACK codebook is determined according to the same rule for SPS release***   [Mod: Thanks. This wording seems to capture the maximum reuse of the mechanism in SPS PDSCH release for Type-2. For Type-1, it is a simple extension based on what has been extensively discussed for SCell dormancy – according to contributions from several companies] |
| OPPO | Support Proposal 3.1 and suggest to rewording the last bullet with more precise wording as following:   * The remaining unused DCI fields and codepoints ~~can be utilized for future use~~ reserved.   [Mod: Agreed] |
| MediaTek | Share the same view with Apple. |
| Mod | Addressed inputs from Apple, OPPO, and MTK |
| Xiaomi | Added our views above.  We cannot support proposal 3.1. As for the main reasons mentioned above, the first one is about the lower beam application latency, but we think the latency is same for DCI format 1\_1/1\_2 with/without DL assignment in the case of PUCCH resource restriction. If long latency is introduced by PDSCH reception, separate PUCCH resource for HARQ-ACK of beam indication and HARQ-ACK of PDSCH can be configured in the case of DCI format 1\_1/1\_2 with DL assignment. For the second one, it is better to be discussed after 1.3. For the third one, it can be discussed in future when future purpose is needed.  In addition, DCI format 1\_1/1\_2 without DL assignment will result in more blind decoding times. |
| NTT Docomo | Support proposal 3.1 |
| MediaTek | Regarding the 3rd bullet of this proposal, we feel TCI field cannot be always present, at least in FR1. Furthermore, unified TCI framework would be an optional feature. If UE doesn’t support this feature (e.g., Rel-15/16 UE), the field may not be configured. We can change the wording to avoid confusion:   * Use at least the existing TCI field (always present if joint/separate TCI is configured/enabled) to signal the following: 1) Joint DL/UL TCI state, 2) DL TCI state, and/or 3) UL TCI state |
| Convida Wireless | OK with proposal 3.1 |
| ZTE | Support proposal 3.1 |
| Qualcomm | We are fine for Proposal 3.1 |
| CATT | We’d suggest to add issue 3.8 to discuss the enhancement of acknowledgement of DCI format 1\_1/1\_2 with DL assignment, where ACK/NAK to the DCI (in addition to PDSCH) may be further needed.  [Mod: Added] |
| Apple | We share the same view with CATT. The ACK/NACK mechanism for DCI with data is not 100% clear. |
| Huawei, HiSilicon | We added our views to some of the listed issues.  We are still concerned and disagree with Proposal 3.1:  As PDSCH can be located within the same slot as PDCCH and there is always a need to wait for ACK transmission opportunity, the differences on beam indication latency using DCI format 1\_1/1\_2 with and without data is insignificant.  A codepoint of TCI field in existing DCI format 1\_1/1\_2 with data can be mapped with joint/separate DL/UL TCI, and can be used to support the case with M/N >1 (if clarified and supported).  Introducing DCI format 1\_1/1\_2 without data for dynamic beam indication is an additional optimization, which will not bring much performance gains (compared with the already agreed solution on using DCI format 1\_1/1\_2 with data and MAC-CE), but will consume extra time/efforts that could be well allocated to other topics.  This is the fourth meeting that the same issue is brought up, trying to over-ride the compromise achieved in November meeting… |
| Mod | Revised proposal to address inputs |
| AT&T | ok with proposal 3.1 |
| Samsung | Although we still prefer to introduce a new DCI format dedicated for beam indication (a cleaner design), we can support proposal 3.1 to respect majority view. This proposal also addresses the most problematic shortcomings of DCI formats 1\_1/1\_2 with DL assignment by adding a few improvements (analogous to known legacy spec features) over the already agreed DCI formats 1\_1/1\_2. |
| NEC | Our views added.  Support the proposal 3.1. And we think more DCI formats can be supported for beam indication, e.g. DCI format 0\_1/0\_2 without data and without CSI request. |
| ZTE | Support the updated proposal 3.1. |
| Spreadtrum | Support proposal 3.1. And we agree with Huawei that we should avoid adding more DCI formats for the same function. Therefore, we suggest to add a sub-bullet: No additional DCI formats will be introduced for joint/separate TCI indication. |
| MediaTek | Support proposal 3.1 |
| LG | We have concern on proposal 3.1. Similarly with Huawei and Xiaomi, the agreed DCI formats 1\_1/1\_2 seem sufficient in most cases. Motivation of dynamic beam switching is weak when there is no data to send. If we’d like to enhance DCI based beam indication further, UL DCI with data needs to be considered with higher priority than the case of having no data to send. |

### Issue 4 (MP-UE)

Table 8 Summary: issue 4

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 4.1 | Additional specification support for enabling UE-initiated   * Panel activation (activating L out of P available UE panels at least for DL/UL measurement), and/or * Panel selection (activating 1 out of L activated UE panels for UL transmission)   Note: If a feature is supported, we will need to discuss whether this applies to activation, selection, or both | * **Not needed (2)**: Ericsson, OPPO * **Indicator/association for panel entity (16)**: IDC, vivo, Lenovo/MoM, ZTE, Qualcomm, Sony, MTK, Fraunhofer IIS/HHI, APT/FGI, CMCC, NTT Docomo, Huawei, HiSi, LG * **Event of panel switch reporting (8)**: CATT, APT/FGI, CMCC, ZTE, Huawei, HiSi, LG * **Transmission process (3)**: Apple, MTK, ZTE |
| 4.2 | Additional specification support for NW-initiated panel selection (via Rel-17 TCI state update)  Note: the use of Rel-17 unified TCI and Rel-17 beam indication for panel selection has been agreed. “Additional” implies on top of this. | * **Not needed (11)**: vivo (implicit), Fraunhofer IIS/HHI (implicit), Ericsson, Xiaomi, OPPO, CATT, Sony, MTK, Nokia/NSB * **Indicator/association for panel entity (4)**: IDC, ZTE, Lenovo/MoM * **Handshake mechanism/panel alignment (4)**: Huawei, HiSi, Qualcomm, CMCC |
| 4.3 | For CSI/beam reporting, what indicates a panel entity (comprising one or more RS resources)? | * **CRI/SSBRI (2)**: LGE (per panel), Sony (2nd priority) * **Association with CSI-RS resource set index (transparent) (9)**: Lenovo/MoM, Samsung, CATT, APT/FGI, Nokia/NSB * **New panel ID (17)**: IDC, vivo, Lenovo/MoM, Xiaomi, NTT Docomo, Spreadtrum, MTK (PEI), APT/FGI, CMCC, Sony (1st priority), ZTE (1st priority), Qualcomm, Huawei, HiSi, LG * **Transmission process index (3):** Apple, MTK, ZTE (2nd priority), [LG (open to discuss how to name panel ID from spec perspective] |
| 4.4 | For beam indication, what indicates a panel entity (comprising one or more RS resources)? | * **CRI/SSBRI/SRI (3)**: vivo, CMCC, Sony (2nd priority) * **CSI-RS resource set index/SRS resource set index (9)**: Fraunhofer IIS/HHI, Samsung, Sony (1st priority), CATT, APT/FGI, Nokia/NSB * **New panel ID (6)**: IDC, LGE, APT/FGI, ZTE, Qualcomm |

The following observation can be made:

* (4.1, 4.3, 4.4) Strong majority supporting additional spec support for enabling UE-initiated panel activation/selection to indicate/refer to a panel entity. This is further delineated in 4.3 and 4.4 in terms of the options. For each of 4.3 and 4.4, two most supported options can be listed for further down selection.

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

**Proposal 4.1**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection,

* For CSI/beam measurement/reporting, down select from the following candidates:
  + Opt1-1: A panel entity is referring to an existing CSI-RS resource set index within CSI/beam measurement
    - The CSI-RS resource set is only measured by the corresponding panel
  + Opt1-2: A panel entity is referring to a new panel ID within CSI/beam reporting
    - FFS: Detailed design of the new panel ID
    - Note: The association between the new panel ID and the panel entity is fully up to UE implementation
  + The duration in which the above panel entity reference is valid and the respective setting are FFS
* For beam indication, down select from the following candidates:
  + Opt 2-1: Association between CSI-RS resource set index/SRS resource set index and TCI state
  + Opt 2-2: Association between a new panel ID with TCI state
    - FFS: Detailed design of the new panel ID, and whether it is the same panel ID as that in Opt1-2
  + Opt 2-3: No additional specification support
  + The duration in which the above association is valid and the respective setting are FFS

Table 9 Additional inputs: issue 4

|  |  |
| --- | --- |
| **Company** | **Input** |
| CMCC | We have provided our views above |
| Nokia/NSB | Issue 4.1: Not clear what is the discussion point. Is this to decide whether UE oriented operation is supported or to find specification impact ‘if’ UE oriented operation is supported?  [Mod] UE-initiated panel selection/activation has been agreed in RAN1#103-e. But whether this requires additional spec impact or not has not been agreed. So the purpose of 4.1 is to conclude whether additional spec impact is needed.   * We support UE initiated UL panel activation, but prefer further discussion on UE oriented UL panel selection.   [Mod] Please see above. Both have been agreed, but the need for spec support is FFS   * We do not see necessity of specification to support UE oriented panel activation. But there should be a specification impact, if UE oriented panel selection is supported. |
| Sony | Add and modify our views. |
| ZTE | Besides, the state of UE panel should be reported, including DL only, and both DL and UL. |
| Mod | Added FL proposal |
| Xiaomi | Updated our views above. |
| NTT Docomo | We suggest discussing CSI/beam reporting (issue 4.3) first. Panel information in CSI/beam reporting is important to align information between gNB and UE of which panel is used for CSI/beam meas./report, so that gNB can make proper configuration/indication of UL Tx in case different panels constitute different numbers of antenna ports/numbers of beams/etc.  Depending on the progress of panel information in CSI/beam reporting (issue 4.3), we can further discuss panel information in beam indication. If panel information is included in CSI/beam reporting,   * If L1 metrics of one panel can be reported for one CRI/SSBRI, CRI/SSBRI in TCI state can represent a panel. * If L1 metrics of multiple panels can be reported for one CRI/SSBRI, additional panel information may be needed in TCI state for beam indication.   [Mod: Thank you. Based on the comments so far it may be possible to proceed in the direction of proposal 4.1. But if not, we can proceed this way] |
| MediaTek | Regarding Opt1-1/Opt1-2, we think they are used differently within the CSI framework. For Opt1-1, to our understanding, CSI/beam measurement is performed in panel specific according to existing CSI-RS resource set index. However, no panel-related info has to be provided within CSI/beam reporting. For Opt1-2, CSI/beam measurement is performed without any restriction, and the panel-related info is provided within CSI/beam reporting according to UE panel activation/selection. In summary, we propose some changes for clarification.  Regarding Option1-2, we would like to further add one note to clarify that the association between the new panel ID and the panel entity is up to UE decision.  Regarding beam indication, we see not all companies supporting panel ID or transmission process index (14+3) for CSI/beam reporting also support panel ID for beam indication (7). Thus, we think no additional specification support could be one option for further study.  **Proposal 4.1**: On Rel.17 enhancements to facilitate UL beam selection for MP-UE, support additional specification to facilitate indication/association of panel entity for enabling UE-initiated panel activation and selection. Down select from the following candidate schemes:   * For CSI/beam measurement/reporting:   + Opt1-1: A panel entity is associated with an existing CSI-RS resource set index within CSI/beam measurement   + Opt1-2: A panel entity is associated with a new panel ID within CSI/beam reporting     - FFS: Detailed design of the new panel ID     - Note: The association between the new panel ID and the panel entity is fully up to UE implementation * For beam indication:   + Opt 2-1: Association between CSI-RS resource set index/SRS resource set index and TCI state   + Opt 2-2: Association between a new panel ID with TCI state     - FFS: Detailed design of the new panel ID, and whether it is the same panel ID as that in Opt1-2   + Opt 2-3: No additional specification support   Some comments to Opt1-1. For CSI/beam measurement/reporting, it is more reasonable that the association between RS resource (i.e., gNB beam) and corresponding UE panel is done by UE according to measurement results and UE-initiated panel activation/selection. We fail to see how NW can group a set of RS resources (i.e., gNB beams) and enforce UE to measure them by a certain UE panel, and how this can facilitate UE-initiated panel activation and selection.  [Mod: Good points. Please check revised version] |
| Apple | We have concern for the term panel ID or panel entity ID. We should use a logical term like antenna port group ID or transmission process ID.  [Mod: ‘Panel entity’ is based on the previous agreement so it is better to progress from that term since it has been defined. Otherwise we would have to restart the discussion ☹]  We think the panel associated with a DL beam should not always be consistent. So we think more discussion could be needed for opt 1-1 and 1-2, e.g. whether this association is consistent or not, or we assume there should be an effective time window for a report.  [Mod: Please check revised version – I added the time issue]  In addition, we do not think NW should control UE panel. Thus, we do not support opt 2-1 or opt 2-2.  [Mod: Opt 2-3 is added] |
| ZTE | ‘CSI framework’ is a little bit confusing, regarding first/second sub-sub-bullet. We do not have strong preference on the title of this ID, but the usage or information corresponding to the ID should be clarified.  [Mod: Good point, please check latest version]  For instance, this ID corresponds to a maximum number of layers to be supported by the UE. |
| Qualcomm | We are generally fine for the proposal. Suggest to add a sub-bullet as below in red to clarify the meaning of Option 1-1, if that is the definition.   * For CSI/beam reporting:   + Opt1-1: Reference to existing CSI-RS resource set index within CSI framework     - The CSI-RS resource set is only measured by the corresponding panel   + Opt1-2: Reference to a new panel ID within CSI framework     - FFS: Detailed design of the new panel ID   [Mod: Good point, done] |
| vivo | We are supportive of the direction.  Proposal 4.1: On Rel.17 enhancements to facilitate UL beam selection for MP-UE, support additional specification to facilitate indication/association of panel entity for enabling UE-initiated panel activation and selection. Down select from the following candidate schemes:   * For CSI/beam reporting:   + Opt1-1: The panel entity is referring to existing CSI-RS resource set index within CSI framework     - The CSI-RS resource set is only measured by the corresponding panel   + Opt1-2: The panel entity is referring to a new panel ID within CSI framework     - FFS: Detailed design of the new panel ID * For beam indication:   + Opt 2-1: Association between CSI-RS resource set index/SRS resource set index and TCI state   + Opt 2-2: Association between a new panel ID with TCI state     - FFS: Detailed design of the new panel ID, and whether it is the same panel ID as that in Opt1-2   [Mod: This reads better, added] |
| Huawei, HiSilicon | We added our views to some of the listed issues.  Support Proposal 4.1 in principle. And we hope that after reporting, gNB can be assured about UE panel status, so that fast UL panel switching can be made possible… |
| Mod | Revised proposal to address inputs |
| Samsung | Support Proposal 4.1, with a note (in red below) to clarify that the correspondence b/w a CSI-RS resource set and a physical panel is up to UE (i.e. UE doesn’t need to reveal it)  **Proposal 4.1**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection,   * For CSI/beam measurement/reporting, down select from the following candidates:   + Opt1-1: A panel entity is referring to an existing CSI-RS resource set index within CSI/beam measurement     - The CSI-RS resource set is only measured by the corresponding panel       * Note: the correspondence b/w a CSI-RS resource set and a physical panel is up to UE. * …. |
| NEC | Support proposal 4.1 |
| ZTE | Support the updated proposal 4.1 |
| OPPO | In the agreement of RAN1#104 meeting, we agreed that “For one RS resource, the corresponding panel entity may vary and is controlled by the UE”. In beam indication as defined rel17 unified TCI state, the gNB indicate a UL TCI through joint TCI state or a UL TCI state and the UL TCI is indicted through a DL RS or SRS. Combined with the agreement we made in RAN1#104 meeting, we do not need enhance beam indication for UL panel selection. The gNB just indicate one UL TCI and the UE would choose the proper UL panel/beam according the mapping which is controlled by the UE. Thus, we suggest to remove the beam indication part in the proposal.  Regarding the beam measurement/reporting part, Opt1-1 seems not correct technically. The mapping between panel entity and CSI-RS resource shall be controlled by UE as agreed in last meeting. Generally, the UE can determine the mapping between panel and CSI-RS according to the downlink beam measurement (assuming UE have beam correspondence). However, the wording Opt1-1 seems to suggest that the gNB control the mapping between the CSI-RS resource and UE panel/beam, which does not align with the agreement. Regarding Opt1-2: it intends to introduce a new panel ID. That has been discussed a lot in rel16 and we all know the outputs of the discussion. So, what is the case for listing it here again. Furthermore, from our perspective, another option is we do not need additional specification support for beam measurement and reporting. The reason is: the UE determines the on/off of a tx panel according many factors. If the UE decides to turn off one Tx panel due to some reasons, the UE won’t use it to conduct beam measurement and reporting. The assumption that the UE turns on all the panel to measure beam and then turn off some panel for transmission is not the real UE operation status. Thus, here is our suggestions on revising the proposal for further discussion:  Change #1: Update Opt 1-1 as follows:   * + Opt1-1: A panel entity is referring to an ~~existing~~ reported CSI-RS resource ~~set index~~ within CSI/beam measurement     - ~~The CSI-RS resource set is only measured by the corresponding panel~~   Change #2: add one more Option:   * + Opt1-3: No additional specification support.   Change #3: delete the part of beam indication. as we explained, if we follow the rel17 unified TCI framework, there is no need for extra enhancement for beam indication:   * ~~For beam indication, down select from the following candidates:~~   + ~~Opt 2-1: Association between CSI-RS resource set index/SRS resource set index and TCI state~~   + ~~Opt 2-2: Association between a new panel ID with TCI state~~     - ~~FFS: Detailed design of the new panel ID, and whether it is the same panel ID as that in Opt1-2~~   + ~~Opt 2-3: No additional specification support~~   + ~~The duration in which the above association is valid and the respective setting are FFS~~ |
| Spreadtrum | Support Proposal 4.1 in principle.  For Opt1-1, we are not clear whether this correspondence means CSI-RS resource set and a panel entity are associated before beam measurement or after beam reporting. |
| MediaTek | Share similar view with OPPO. Opt 1-1 in current proposal seems to be conflicted with our previous agreement, thus we prefer to remove it. We are also okay to add change #2 suggested by OPPO as a compromise. We see whether new panel ID is needed will depend on how we design and use it in the end. |
| LG | Added our view in the table.  We support Proposal 4.1 in principle. For Opt 1-1 and Opt 2-1, it needs to allow SSB resource set as well as CSI-RS resource set to our understanding. Overall, the functionality of 1-1 vs 1-2 and 2-1 vs 2-2 are similar but considering many different issues related to panel (e.g. MPE, panel-switching/activation time gap, timing error group in Positioning, etc.) and forward-compatibility, we think that it will be more efficient to introduce a panel-specific ID. How to name that ID in specification can be discussed later, e.g. transmission process ID, etc. |

### Issue 5 (MPE mitigation)

Table 10 Summary: issue 5

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 5.1 | Whether to support at least one the following:   * {Rel.16 P-MPR based (beam/panel-level)} + {A}, where A is either Opt1A, Opt1B, Opt1C, or Opt1D:   + Option 1A: Virtual PHR or a modified version associated with each activated UL TCI or, if applicable, joint TCI   + Option 1B: {SSBRI(s)/CRI(s) and/or panel indication}   + Option 1C: {SSBRI(s)/CRI(s) and/or panel indication} + virtual PHR or a modified version associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured)   + Option 1D: No additional reporting quantity * {SSBRI(s)/CRI(s) and/or panel indication} + {A}, where A is either Opt2A, Opt2B, Opt2A+ Opt2B, or Option 2C   + Option 2A: 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)   + Option 2B: Virtual PHR or a modified version associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured)   + Option 2C: No additional reporting quantity | Rel-16 P-MPR based:   * **Option 1A (6)**: Nokia/NSB, NTT Docomo, OPPO, Lenovo/MoM * **Option 1B (2)**: Sony, Intel * **Option 1C (3)**: ZTE, Apple, Qualcomm * **Option 1D (6)**: vivo, Spreadtrum, MTK, Xiaomi, Huawei, HiSi   SSBRI/CRI-based:   * **Option 2A (8)**: CMCC, Ericsson (*UL-RSRP = L1-RSRP – PDL + PUL*), Samsung (modified RSRP), NTT Docomo, CATT (scaled RSRP), MTK, Sony, LGE * **Option 2B (4)**: CATT, ZTE, Convida, Qualcomm * **Option 2A+2B** (in one report) (3): Nokia/NSB, Apple * **Option 2C (2)**: Spreadtrum, Xiaomi * **Other option**(s): IDC (TCI state group indication + gNB confirmation) |
| 5.2 | If Opt1A/B/C/D in 5.1 is supported:   * Alt1. Beam-level reporting * Alt2. Panel-level reporting | **Alt1 (5)**: Nokia/NSB, MTK (associated with active TCI states), Qualcomm, Sony  **Alt2 (10)**: vivo, Lenovo/MoM, Xiaomi, Spreadtrum, Lenovo/MoM, NTT Docomo, Huawei, HiSi |
| 5.3 | If Opt2A/B/C 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 (9)**: IDC, Nokia/NSB, MTK, Sony, ZTE (1st priority), Qualcomm, NTT Docomo, CATT  **Alt2 (6)**: Lenovo/MoM, Xiaomi, Samsung, LGE, MTK |
| 5.4 | Reporting mechanism | **UE-initiated (event-triggered) without NW triggering via CSI request (8):** Sony, Qualcomm, Samsung, Nokia/NSB (BFR like), ZTE, Huawei, HiSi  **NW triggering via CSI request (just as the regular A-CSI):** |

The following observation can be made:

* (5.1) The two most supported options are Opt1A and Opt2A. To further progress, more detailed technical discussion can be focused on those two options while not precluding the option of not enhancing
  + On gNB confirmation scheme (from, e.g. IDC), it seems to apply to both schemes, and can be left as FFS
* (5.4) There seems to be consensus on UE-initiated (event-triggered) reporting mechanism for MPE mitigation

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

**Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation, in RAN1#104b-e, further discuss to down-select at least one or combine from the following options:

* Opt 1A. {Rel.16 P-MPR based (beam/panel-level)} + Virtual PHR or a modified version associated with each activated UL TCI or, if applicable, joint TCI
* Opt 1D. {Rel.16 P-MPR based (beam/panel-level)}
* 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: How panel-level L1-RSRP [L1-SINR] is reported if L1-RSRP [L1-SINR] is associated with panel
  + FFS: Whether/how to account for MPE effect in L1-RSRP [L1-SINR] report, e.g. by using scaled L1-RSRP [L1-SINR]
  + FFS: Whether/how to enhance existing beam reporting format to support Option 2A

FFS: If gNB confirmation of MPE-based UE reporting is supported

FFS: If differential report is supported when multiple UL beams are reported in the same report

**Proposal 5.2**: On Rel.17 enhancements to facilitate MPE mitigation, the supported UE reporting scheme is UE-initiated (event-triggered)

* This implies that NW triggering (via, e.g. CSI request) is not utilized
* FFS: Definition of triggering event

Table 11 Additional inputs: issue 5

|  |  |
| --- | --- |
| **Company** | **Input** |
| Sony | Add more views. |
| ZTE | In our views, the issue 5.4 reporting mechanism should be discussed firstly for facilitating the final down-selection from the alternatives in Issue 5.1. |
| Mod | Added FL proposal 5.1 |
| Xiaomi | Added our views above. |
| NTT Docomo | For 5.4, for option1, we support to reuse reporting mechanism of R16 PMPR report, i.e., event triggered; for option2, we support to reuse reporting mechanism of CSI/beam reporting, i.e., configured/triggered by NW  [Mod: Added proposal 5.2. Would Docomo-san be fine with event-triggered for Opt2x as well?] |
| MediaTek | Okay to this proposal. It is a down-selection from previous agreements for future down-selection. Regarding Opt2A, there are some FFSs in the previous agreement, and we prefer to add them back to this proposal.   * 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: How panel-level L1-RSRP [L1-SINR] is reported if L1-RSRP [L1-SINR] is associated with panel   + FFS: Whether/how to account for MPE effect in L1-RSRP [L1-SINR] report, e.g. by using scaled L1-RSRP [L1-SINR]   + FFS: Whether/how to enhance existing beam reporting format to support Option 2A   [Mod: Done]  Regarding reporting mechanism, we think this may depend on which option(s) is adopted. For Opt 1A/1D, we think UE-initiated report is natural. For Opt 2A/2D, it is more similar to existing beam reporting at least in our view. |
| Apple | We support the proposal in principle, but we suggest we consider to combine some options. In our understating, option 1A and 2A can be combined so that gNB can calculate the UL Rx power. We suggest we add “or combine” in the main-bullet.   * **Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation, in RAN1#104b-e, discuss and down select or combine from the following options:   + Opt 1A. {Rel.16 P-MPR based (beam/panel-level)} + Virtual PHR or a modified version associated with each activated UL TCI or, if applicable, joint TCI   + Opt 1D. {Rel.16 P-MPR based (beam/panel-level)}   + 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)   + Opt 2C. {SSBRI(s)/CRI(s) and/or panel indication}   + FFS: If gNB confirmation of MPE-based UE reporting is supported   [Mod: Good point] |
| ZTE | We can NOT support this proposal before technical discussion. To be honest, we do not see a clear majority views among those candidates.  [Mod: From the table, 1A, 1D, and 2A seem to be the most supported ones. I removed 2C to be consistent. Please check the latest version and hopefully it is ok to ZTE ☺ Or please suggest some revision]  In our views, the issue 5.4 reporting mechanism should be discussed firstly for facilitating the final down-selection from the alternatives in Issue 5.1. Can we agree that UE-initialized reporting should be supported for MPE mitigation?  [Mod: Added proposal 5.2 (good point)] |
| Intel | We think this proposal needs further discussion. In our view the baseline should be Option 1B. If going with Apple’s suggestion, 1B should also be included in the discussion. |
| Qualcomm | Suggest to add “at least one” in the Proposal 5.1, since the event triggered P-MPR report can be used when the UL beam for regular report fails. In other words, P-MPR report and regular report can coexist for different use cases to our understanding. Also, Suggest to add another FFS at the end.   * **Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation, in RAN1#104b-e, discuss and down select at least one from the following options: * Opt 1A. {Rel.16 P-MPR based (beam/panel-level)} + Virtual PHR or a modified version associated with each activated UL TCI or, if applicable, joint TCI * Opt 1D. {Rel.16 P-MPR based (beam/panel-level)} * 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) * Opt 2C. {SSBRI(s)/CRI(s) and/or panel indication}   FFS: If gNB confirmation of MPE-based UE reporting is supported  FFS: If differential report is supported when multiple UL beams are reported in the same report.  [Mod: Done] |
| Mod | Revised proposal 5.1 to address inputs  Added proposal 5.2 |
| Samsung | We are fine with the proposal except that we suggest to add an FFS for the case when multiple beams are reported in the same report. In our view, all beams don’t need to be UL beams (i.e. dedicated for UL). Some of them can be for UL, and the rest can be normal (i.e. for DL and UL like in Rel. 15.16).  FFS: When multiple beams are reported in the same report, then whether some of them can be dedicated for UL beams (e.g. for MPE mitigation), and the rest can be normal (e.g. for both DL and UL as in Rel. 15/16 beam report) |
| ZTE | We support proposal 5.2.  Regarding proposal 5.1, to be honest, we still fail to understand the full picture of how to make sure the MPE related reporting is useful.   * For Opt 1A, the activated UL TCI state may be quite limited, and candidate RS should be selected from a general beam pools (e.g., up to 64 SSB); * For Opt 1D, we still fail to identify the candidate beam or panels. What is the Rel-17 enhancement? * For Opt 2A, the spec impact/complexity should be well evaluated, and we do not have a clear event-driven UE behavior that can be inherited from Rel-15/16.   Regarding the updated proposal, does it means that ‘combine’ means SSBRI/CRI may be reported along with PHR, also as Intel mentioned? If so, for progress, we suggest to revise Opt-1 a little bit for solving our concerns.   * 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.   + FFS: how to determine the virtual PHR or the modified version. |
| Spreadtrum | Support Proposal 5.1 in principle. For Opt 2A, since there are many modified versions of L1-RSRP, we suggest to add a note that if there’s no consensus on the definition of L1-RSRP, no additional report quantity is supported.  **Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation, in RAN1#104b-e, further discuss to down-select at least one or combine from the following options:   * Opt 1A. {Rel.16 P-MPR based (beam/panel-level)} + Virtual PHR or a modified version associated with each activated UL TCI or, if applicable, joint TCI * Opt 1D. {Rel.16 P-MPR based (beam/panel-level)} * 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: How panel-level L1-RSRP [L1-SINR] is reported if L1-RSRP [L1-SINR] is associated with panel   + FFS: Whether/how to account for MPE effect in L1-RSRP [L1-SINR] report, e.g. by using scaled L1-RSRP [L1-SINR]   + FFS: Whether/how to enhance existing beam reporting format to support Option 2A   + Note: If there’s no consensus on the definition of L1-RSRP, no additional report quantity is supported   FFS: If gNB confirmation of MPE-based UE reporting is supported  FFS: If differential report is supported when multiple UL beams are reported in the same report  Support Proposal 5.2. |
| MediaTek | On Proposal 5.1, we support the FFS added by Samsung. In fact, we believe the issue raised by Samsung is a part of the following FFS.   * + FFS: Whether/how to enhance existing beam reporting format to support Option 2A   On Proposal 5.2, we cannot support it. We don't see UE-initiated report is a good choice at least for Opt 2A. As we mentioned above, Opt 2A can be done by enhancing legacy beam reporting, which is NW-initiated measurement/report (either periodic configure or dynamic activate/trigger). |

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

Table 12 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 | **UE-initiated beam reporting/refinement/selection/activation**:   * UE reports beam/beam-group quality or performs P3 based on measurement after/upon beam indication: Samsung, OPPO (from pre-configured TCI-state-associated resource set), Nokia/NSB (P3) * UE selects beam based on measurement only: OPPO (report selection for alignment), Ericsson (report beam quality, UE assumes gNB follows), Qualcomm, Nokia/NSB (with gNB confirmation), LG * UE selects beam from DCI-based beam-group indication based on measurement: Futurewei (ACK to NW) * UE reports activated beam-group based on measurement: MTK (ACK from NW)   **Semi-static/pre-programmed (RRC) NW-configured beam selection (without beam indication and measurement/reporting)**: NTT Docomo (for HST), Sony (based on predictive trajectory), Qualcomm  **SSB grouping across CCs** (reduce beam training time for CA)**:** Ericsson, Apple  **Aperiodic beam measurement/reporting based on multiple resource sets for facilitating P2+P3/P1**: ZTE |
| 6.2 | Group 2: Reducing activation delay of TCI states and PL-RSs (including other WGs, e.g. RAN4)  Note: A number of companies argued that most of the schemes in this category can be handled exclusively in RAN4 | **Reducing latency of MAC CE based activation/update**:   * TCI state activation or F/T/beam tracking (limited by SSB periodicity): SSB pool tracking (ZTE), A-TRS or AP-CSI-RS triggering via MAC CE/DCI (vivo, Apple), pre-stored QCL properties to avoid measurement (Ericsson, NTT Docomo, Sony, ZTE) * PL-RS (simultaneous/multiple): vivo, Qualcomm (reducing application time), ZTE * SCell TCI state activation: direct (Qualcomm)   **Replacing RRC-based update with MAC CE (or DCI) based update (from NW to UE):**   * Associated NZP CSI-RS info for SRS (NCB based)**:** Lenovo/MoM * QCL relation between SSBs and CSI-RSs: Intel (e.g. to aid hierarchical beam acquisition), vivo, ZTE, Apple   **One-shot timing update**: Ericsson (e.g. upon TCI state update) |

**Proposal 6.1**: On Rel.17 enhancements to facilitate advanced beam refinement/tracking, perform study (for the purpose of down-selection and/or combining) and, if needed, specify the following candidate schemes from Group 1:

{Will add next round}

**Proposal 6.2**: On Rel.17 enhancements to facilitate advanced beam refinement/tracking, perform study (for the purpose of down-selection and/or combining) and, if needed, specify the following candidate schemes from Group 2:

{Will add next round}

Table 13 Additional inputs: issue 6

|  |  |
| --- | --- |
| **Company** | **Input** |
| Sony | Add more preference. |
| ZTE | One more alternative for group-1 is added: Aperiodic beam measurement/reporting based on multiple resource sets for facilitating P2+P3/P1. Furthermore, we can consider additional UE report to aid P2/P3 related measurement/report configuration (triggering request, and the number of candidate RS(s)). |
| Futurewei | We share the same view that most of the schemes in Group 2 can be handled exclusively in RAN4. |
| NTT Docomo | In Group2, to reduce the TCI state activation delay, RAN4 spec. should be updated. So, we’d like to send LS to inform the issue and potential solution to RAN4. |
| Mod | Revised Table 12 based on further reading of each company’s Tdoc |

## Appendix A: Collection of Agreements up to RAN1#104-e

**Issue 1**

* [Issue 1] For Rel.17 NR FeMIMO, on the unified TCI framework
  1. Support joint TCI for DL and UL based on and analogous to Rel.15/16 DL TCI framework
     + The term “TCI” at least comprises a TCI state that includes at least one source RS to provide a reference (UE assumption) for determining QCL and/or spatial filter
     + The source reference signal(s) in M TCIs provide common QCL information at least for UE-dedicated reception on PDSCH and all or subset of CORESETs in a CC
       - FFS: Optionally this common QCL information can also apply to CSI-RS resource for CSI, CSI-RS resource for BM, and CSI-RS for tracking
       - FFS: Applicability on PDSCH includes PDSCH default beam
       - Working Assumption: Select between M=1 and M>=1
     + The source reference signal(s) in N TCIs provide a reference for determining common UL TX spatial filter(s) at least for dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC,
       - Optionally, this UL TX spatial filter can also apply to all SRS resources in resource set(s) configured for antenna switching/codebook-based/non-codebook-based UL transmissions
       - FFS: applicability of this UL TX spatial filter to SRS configured for beam management (BM)
       - FFS: PUSCH port determination based on the TCI, e.g., to be mapped with SRS ports analogous to Rel.15/16
       - Working Assumption: Select between N=1 and N>=1
     + FFS: extension to common QCL information applied to only some of the CORESETs or PUCCH resources in a CC, e.g. for mTRP
     + FFS: When used for the purpose of joint beam indication for UL and DL, whether a joint TCI pool for DL and UL dedicated for the purpose is used, or the same TCI pool as that used for the purpose of separate DL/UL beam indication is used
     + Note: The resulting beam indication directly refers to the associated source RS(s)
     + FFS (RAN1#103-e): Details on extension to intra- and inter-band CA
     + FFS (RAN1#103-e): The supported number of active TCI states considering factors such as multi-TRP and issue 6
     + FFS (RAN1#103-e): Applicable QCL types, and co-existence with DL TCI and spatial relation indication in Rel.15/16
  2. In RAN1#103-e, investigate, for the purpose of down selection, the following alternatives for accommodating the case of separate beam indication for UL and DL
     + Alt1. Utilize the joint TCI to include references for both DL and UL beams
     + Alt2. Utilize two separate TCI states, one for DL and one for UL. The TCI state for the DL is the same as agreed in 1a. The TCI state for the UL can be newly introduced.
       - Alt 2-1: The UL TCI state is taken from the same pool of TCI states as the DL TCI state
       - Alt 2-2: The UL TCI state is taken from another pool of TCI states than the DL TCI state
     + Note: The resulting beam indication directly refers to the associated source RS(s)
     + FFS (RAN1#103-e): Details on extension to intra- and inter-band CA
     + Note: This may be related to issue 5 as well as other reasons for different TCIs such as network flexibility/scheduling
  3. Support the use of SSB/CSI-RS for BM and/or SRS for BM as source RS to determine a UL TX spatial filter in the unified TCI framework
     + Whether the UL TX spatial filter corresponds to UL TCI (separate from DL TCI) depends on the outcome of 1b) above
     + FFS: Support the use of non-BM CSI-RS and/or non-BM SRS in addition
  4. In RAN1#103-e, decide if SRS for BM can be configured as a source RS to represent a DL RX spatial filter in the unified TCI framework
  5. In RAN1#103-e, decide/finalize all other parameters included in or concurrent with (but not included in) the TCI, e.g. UL-PC-related parameters (involving P0/alpha, PL RS, and/or closed loop index), UL-timing-related parameters
  6. In RAN1#103-e, identify issues pertaining to alignment between DL and UL default beam assumptions using the unified TCI framework

On Rel-17 unified TCI framework, to accommodate the case of separate beam indication for UL and DL:

* Utilize two separate TCI states, one for DL and one for UL.
  + FFS: Contents of separate UL TCI state
  + Note: For FR1, UE does not expect UL TCI to provide a reference for determining common UL TX spatial filter(s), if UL TCI is supported for FR1
* For the separate DL TCI:
  + The source reference signal(s) in M TCIs provide QCL information at least for UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC
* For the separate UL TCI:
  + The source reference signal(s) in N TCIs provide a reference for determining common UL TX spatial filter(s) at least for dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC
  + Optionally, this UL TX spatial filter can also apply to all SRS resources in resource set(s) configured for antenna switching/codebook-based/non-codebook-based UL transmissions
* FFS: Whether the UL TCI state is taken from a common/same or separate TCI state pool from DL TCI state
  + Note that TCI state pool for joint DL and UL beam indication is still FFS
* FFS: Whether Rel.17 supports TCI configured for single channel (e.g. PDSCH only, single CORESET)
* Note: This does not preclude the type of UE supporting only 1 beam tracking loop, i.e. UE reports value of 1 in UE FG 2-62.

**Conclusion**

There is no consensus in RAN1 to include the following as part of RAN1 agreement for AI 8.1.1 in RAN1 #103e:

* FFS beam indication for the TCI state assumption/update for the following cases:
  + The beam indication UE-specific DCI (i.e. the CORESETs with the DCI received by UE), the scheduled PDSCH by the DCI and the associated PUCCH for the acknowledgment of the beam indication DCI

Non-UE-specific CORESETs and PUSCH/PDSCH scheduled/activated and PUCCH transmission triggered by non-UE-specific CORESETs

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:

* The above applies to intra-band CA
* The above applies to joint DL/UL and separate DL/UL beam indications
* Just as Rel.16, the RS in the TCI state that provides QCL-TypeA [or QCL-TypeB] shall be in the same CC as the target channel or RS
* The common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs
* FFS: The above also applies to inter-band CA
* FFS: TCI state pool for CA
  + Opt-1: sharing a single RRC TCI state pool for the set of configured CCs, e.g., cell-group TCI state pool, or reuse TCI state pool for PDSCH in a reference cell; A CC ID for QCL-Type A RS is absent in a TCI state, and the CC ID for QCL-Type A RS is determined according to a target CC of the TCI state.
    - FFS: Whether it is possible that a single TCI state in the pool includes all source RSs from different CCs
  + Opt-2: configuring RRC TCI state pool per individual CC
* FFS: Whether the Rel-17 common beam update across multiple CCs applies to beam indication for single channel (e.g. PDSCH only, single CORESET), a subset of channels, or all channels

On Rel-17 unified TCI framework:

* A pool of joint DL/UL TCI state is used for joint DL/UL TCI state update (beam indication).
* FFS: The pool for separate DL and UL TCI state update (beam indication)
* Note: Here, TCI state pool refers to a pool configured via higher-layer (RRC) signaling
* FFS: Whether joint TCI may include UL specific parameter(s) such as UL PC/timing parameters, PL RS, panel-related indication,etc. and if it is included, it is used only for UL transmission of the DL and UL transmissions to which the joint TCI is applied

**Conclusion**

On Rel.17 unified TCI framework, based on the agreements in RAN1#102-e and 103-e, the following terms are defined as follows (at least for the purpose of discussion and reaching agreements).

For M=1:

* DL TCI: The source reference signal(s) (analogous to Rel.15, two, if qcl\_Type2 is configured in addition to qcl\_Type1) in the DL TCI provides QCL information at least for UE-dedicated reception on PDSCH and all of CORESETs in a CC

For N=1:

* UL TCI: The source reference signal in the UL TCI provides a reference for determining UL TX spatial filter at least for dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources in a CC

For M=N=1:

* Joint DL/UL TCI: A TCI refers to at least a common source reference RS used for determining both the DL QCL information and the UL TX spatial filter.
* Separate DL/UL TCI: The DL TCI and UL TCI are distinct (therefore, separate).

For M>1:

* DL TCI: Each of the M source reference signals (or 2M, if qcl\_Type2 is configured in addition to qcl\_Type1) in the M DL TCIs provides QCL information at least for one of the M beam pair links for UE-dedicated receptions on PDSCH and/or subset of CORESETs in a CC

For N>1:

* UL TCI: Each of the N source reference signals in the N UL TCIs provide a reference for determining UL TX spatial filter at least for one of the N beam pair links associated with dynamic-grant(s)/configured-grant(s) based PUSCH, and/or subset of dedicated PUCCH resources in a CC

For M>1 and/or N>1:

* Joint DL/UL TCI: A TCI refers to at least a common source reference RS used for determining both the DL QCL information and the UL TX spatial filter. In this case, M=N.
* Separate DL/UL TCI: The M DL TCIs and N UL TCIs are distinct (therefore, separate).

Note: Other TCI types/terms such as “common TCI” are not used.

On Rel.17 unified TCI framework, the supported source/target QCL relations in the current TS38.214 V16.4.0 is supported for QCL Type D.

* Note: This implies that the following source RS types for DL QCL (Type D, for DL RX spatial filter reference) information for DL UE-dedicated reception on PDSCH and all/subset of CORESETs are supported:
  + CSI-RS for beam management
  + CSI-RS for tracking
* FFS (to be decided by RAN1#104bis-e): If SSB, CSI-RS for CSI, and/or SRS for BM are also supported as source RS types

On Rel.17 unified TCI framework, the following source RS types for UL TX spatial filter are supported:

* CSI-RS for tracking
* Note: SRS for BM, SSB, and CSI-RS for BM have been agreed in RAN1#102-e
* FFS (to be decided by RAN1#104bis-e): non-BM CSI-RS other than for tracking, non-BM SRS

On Rel.17 unified TCI framework:

* For joint and separate DL/UL TCI, DL large scale QCL properties are inferred from one (qcl-Type1) or two RSs (qcl-Type1 and qcl-Type2) analogous to Rel.15/16
* For joint DL/UL TCI, UL spatial filter is derived from the RS of DL QCL Type D

On Rel.17 unified TCI framework, by RAN1#104bis-e, down select or modify at least one from the following alternatives:

* Alt1. A UE can be dynamically indicated with either joint DL/UL TCI or separate DL/UL TCI
  + Details on dynamic indication are FFS
  + FFS: UE capability for the support of joint DL/UL TCI and/or separate DL/UL TCI
* Alt2A. A UE can be configured with either joint DL/UL TCI or separate DL/UL TCI via RRC signaling
* Alt2B. A UE can be configured with either joint DL/UL TCI, separate DL/UL TCI, or both via RRC signaling
* Alt3. A UE can be configured with either joint DL/UL TCI or separate DL/UL TCI via MAC CE signaling
  + Details on how this is signaled in relation to TCI activation are FFS

On Rel.17 unified TCI framework, decide by RAN1#104bis-e:

* Whether DL or, if applicable, joint TCI also applies to the following signals. If not, FFS any other enhancement over Rel.15/16:
  + CSI-RS resources for CSI
  + Some CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)
  + CSI-RS for tracking
* Whether UL or, if applicable, joint TCI also applies to the following signals
  + Some SRS resources or resource sets for BM

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) is at least associated with UL channel or UL RS
* Select or modify from one of the following alternatives by RAN1#104bis-e for PUCCH, PUSCH, and SRS separately:
  + Alt1. The setting of (P0, alpha, closed loop index) is also associated with UL or (if applicable) joint TCI state
  + Alt2. The setting of (P0, alpha, closed loop index) is included with UL or (if applicable) joint TCI state
  + Alt3. The setting of (P0, alpha, closed loop index) is neither associated with nor included in UL or (if applicable) joint TCI state
  + Alt4. The setting of (P0, alpha, closed loop index) is determined as in Rel-16 without enhancement

On Rel.17 unified TCI framework:

* Select at least one of the following alternatives by RAN1#104bis-e for path-loss measurement (PL-RS):
  + Alt1. PL-RS can be included in UL TCI state or (if applicable) joint TCI state.
    - FFS: Whether it is always included or not. If not included, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state.
  + Alt2. PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state
    - FFS: Exact association mechanism
    - FFS: Whether it is always associated or not. If not associated, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state
  + Alt3. The periodic DL-RS used as a source RS for determining spatial TX filter can be used as PL-RS. In case the periodic DL-RS used as a source RS for determining spatial TX filter is not used as PL-RS, reuse Rel.16 procedure with the same signaling structure (MAC CE+SRI field in UL-related DCI) to indicate PL-RS for UL transmission with minimum enhancement (e.g. pertaining to the use for PUCCH, or using default PL-RS)
    - PL-RS is not additionally configured in or associated to UL TCI state or (if applicable) joint TCI state
  + Alt4. UE calculates path-loss based on periodic DL RS configured as the source RS or a periodic QCL-Type-D/spatialRelationInfo source of the source RS in UL TCI state or (if applicable) joint TCI state
    - FFS: Whether UE can calculate path-loss based on DL periodic RS for path-loss calculation for UL RS in the UL TCI
* FFS: Application time of PL-RS
* NOTE: As in Rel-16, a UE does not expect to simultaneously maintain more than four path-loss estimates per serving cell for all PUSCH/PUCCH/SRS transmissions
  + FFS: investigate the condition(s) agreed in Rel-17 and, if needed, study whether a UE can simultaneously maintain more than four path-loss estimates

**Issue 2**

* [Issue 2] For Rel.17 NR FeMIMO, on L1/L2-centric inter-cell mobility:
  1. In RAN1#103-e, finalize scope and use cases for L1/L2-centric inter-cell mobility, including:
     + Applicability in various non-CA and CA setups such as intra-band and inter-band CA
     + Use cases in comparison to Rel.15 L3-based handover (HO) taking into account potential extension of DAPS-based Rel.16 mobility enhancement to FR2-FR2 HO
     + The extent of RAN2 impact (MAC CE, RRC, user plane protocols)
     + Network architecture, e.g. NSA vs. SA, inter-RAT scenarios
  2. In RAN1#103-e, depending on the outcome of 2a), further identify additional components –along with the associated alternatives –required for supporting inter-cell mobility based on the same unified TCI framework as that for intra-cell mobility (including dynamic TCI state update signaling), including
     + Method(s) for incorporating non-serving cell information associated with TCI
     + Method(s) for DL measurements and UE reporting (e.g. L1-RSRP) associated with non-serving cell(s)
     + UE behavior for reception of signals and non-UE-specific control and data channels associated with non-serving cell(s)
     + UL-related enhancements, e.g. related to RA procedure including TA
     + Beam-level event-driven mechanism for L1/L2-centric inter-cell mobility

On Rel-17 enhancements to enable L1/L2-centric inter-cell mobility:

* The following use cases are assumed:
  + Network architecture:
    - NSA, i.e. LTE PCell and NR-PSCell
    - SA
  + Intra-band CA
    - FFS: If inter-band CA is also included
  + Intra- RAT (excluding inter-RAT)
  + Intra-frequency scenario:
    - The SSBs of non-serving cells have the same center frequency and SCS as the SSBs of the serving cell
    - An SSB of a non-serving cell is associated with a PCI different from the PCI of the serving cell
    - FFS: Support for inter-frequency scenario
  + FFS: Whether to support intra-DU only operation, or whether inter-DU is also allowed
* The following enhancement scope is assumed:
  + Facilitating measurement and reporting of non-serving RSs via incorporating non-serving cell info with some TCI(s), along with the necessary measurement and reporting scheme(s)
    - FFS: Detailed/exact method(s)
    - FFS: Whether this also implies the support of beam indication (TCI state update along with the necessary TCI state activation) for TCI(s) associated with non-serving cell RS(s)
    - FFS: Metric for the measurement and reporting, e.g. L1-RSRP or L3-RSRP or time- or spatial-domain-filtered L1-RSRP
    - FFS: Beam-level event-driven mechanism, using serving cell RS and/or non-serving cell RS
  + Facilitate serving cell to provide configurations for non-serving cell SSBs via RRC
    - FFS: details for the configurations, e.g. time/frequency location, transmission power, etc.
    - FFS: other information needed for inter-cell mobility
  + Note: In RAN1's understanding, non-serving cell SSB and non-serving cell RS can be part of the serving cell configuration
* FFS: The following enhancement scope is assumed by RAN1:
  + Whether RRC reconfiguration signaling is needed or not when a TCI associated with non-serving cell RS is indicated
    - A non-serving cell RS is an RS that is or has an SSB of a non-serving cell as direct or indirect QCL source
    - This implies no C-RNTI update when UE receives DL channel RS associated to non-serving cell RS as QCL source.
    - FFS whether TCI associated with non-serving cell can be indicated to or are applicable for all channels.
  + Whether some RRC parameters need to be updated without additional RRC signaling, e.g. some RRC parameters are pre-configured, which are associated with TCI states with neighbor cell RS as QCL source
  + Whether UE needs/can change serving cell during L1/L2-centric inter-cell mobility.
  + The above assumption to be verified by RAN2

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

* A quality of up to K beams associated at least with non-serving cell(s) can be reported in a single CSI reporting instance
  + For each beam, the UE can report at least: (1) a Measured RS Indicator, and (2) a Beam Metric associated with the Measured RS Indicator
  + FFS: Maximum value of K
  + FFS: If K is fixed, configured, reported by UE capability, or dynamically selected
  + FFS: The type of beam metric (e.g. L1-RSRP, L3-RSRP, or hybrid L1/L3-RSRP) and related measurement behavior
  + FFS: Whether or not beam reporting associated with non-serving cell(s) can be mixed with that with serving-cell in one reporting instance

At the end of RAN1#104-e, send an LS to RAN2 with all the RAN1-related inter-cell mobility agreements done so far during Rel17.

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

* Rel.15 L1-RSRP is used as reporting quantity for measurement and reporting of non-serving-cell(s)
  + Support SSB as a measurement RS for L1/L2-centric inter-cell mobility and inter-cell mTRP, and Rel.15 SS-RSRP calculated from SSB of non-serving cell(s)
    - FFS: Whether the measurement for SS-RSRP is limited within SMTC
    - FFS: Detailed reporting method, e.g. via including existing L1-RSRP report, UE-initiated report etc.
  + FFS: Whether or not to support CSI-RS (for e.g. mobility and/or tracking) of non-serving cell(s) as a measurement RS for L1/L2-centric inter-cell mobility and inter-cell mTRP. If the support of CSI-RS (for e.g. mobility and/or tracking) of non-serving cell(s) as a measurement RS for L1/L2-centric inter-cell mobility and inter-cell mTRP is confirmed, Rel.15 CSI-RSRP is also supported
    - Whether the support applies to CSI-RS with or without QCL source, or both
  + FFS: The number of non-serving cell(s) for measurement/reporting
  + FFS: time behavior of the reporting, i.e. periodic, semi-persistent, aperiodic, or UE-initiated
* FFS: If other reporting quantities are supported, e.g. L3-RSRP, hybrid L1/L3-RSRP
* FFS: Dynamic activation/deactivation/selection of the beam measurement on the RS(s) associated with non-serving cell(s) via MAC CE
* FFS: Timing assumption (e.g. time of arrival and time of the measurement) for measurement of non-serving cell RS measurement

On Rel.17 enhancements for L1/L2-centric inter-cell mobility,

* Discuss whether to support at least the source RS types already agreed for intra-cell mobility for the purpose of referencing to non-serving cell(s). Note: This implies the following source RS(s):
  + CSI-RS for BM configured for non-serving cell(s) for DL QCL and UL TX spatial references
  + CSI-RS for tracking (TRS) configured for non-serving cell(s) for DL QCL and UL TX spatial references
  + SSB configured for non-serving cell(s) for UL TX spatial references
  + SRS for BM configured for non-serving cell(s) for UL TX spatial references
  + FFS: whether to support CSI-RS for mobility
  + FFS: whether to support other source RS(s) potentially agreed later for intra-cell mobility
  + FFS: whether to support CSI-RS for BM and tracking configured for non-serving cell(s) and without non-serving cell SSB as QCL-TypeD source

**Issue 3**

* [Issue 3] For Rel.17 NR FeMIMO, on dynamic TCI state update signaling medium:
  1. In RAN1#103-e, investigate, for the purpose of down selection, the following alternatives:
     + Alt1. DCI
     + Alt2. MAC CE
     + Note: Combination between DCI and MAC CE for, e.g. different use cases or control information partitioning can also be considered
     + Note: The study should consider factors such as feasibility for pertinent use cases, performance (based on at least the agreed EVM), overhead (including PDCCH capacity), latency, flexibility, reliability including the support of retransmission
     + Note: This may be related to outcome of issue 1a), 1b), and 6a)
  2. In RAN1#103-e, depending on the outcome of 3a), identify candidates for more detailed design issues for the dynamic TCI state update such as
     + Exact content
     + Signaling format
     + Reliability aspects including the support of retransmission
     + Extensions, including the support of UE-group (in contrast to UE-dedicated) signaling

On beam indication signaling medium to support joint or separate DL/UL beam indication in Rel.17 unified TCI framework:

* Support L1-based beam indication using at least UE-specific (unicast) DCI to indicate joint or separate DL/UL beam indication from the active TCI states
  + The existing DCI formats 1\_1 and 1\_2 are reused for beam indication
  + Support a mechanism for UE to acknowledge successful decoding of beam indication
    - The ACK/NAK of the PDSCH scheduled by the DCI carrying the beam indication can be used as an ACK also for the DCI
    - FFS: Whether any additional specification support is needed
* Support activation of one or more TCI states via MAC CE analogous to Rel.15/16:
  + At least for the single activated TCI state, the activated TCI state is applied
  + The content for the MAC CE is determined based on the outcome of issue 1
  + FFS: If supported, default TCI state when more than one TCI states are activated by MAC CE
  + Note: There is no implications on the support of single TRP or multi-TRP
* FFS: Additional enhancement such as L1-based beam indication with group-common DCI
* FFS: Whether the Rel.17 beam indication can also apply to beam indication for single channel (e.g. PDSCH only, single CORESET) or a subset of channels
* FFS: Additional details on extending the support of L1-based beam indication when separate UL (from DL) common beam indication is configured

In RAN1#104-e, on the Rel-17 L1-based TCI state update (beam indication) for the unified TCI framework, interested companies are to provide the following:

* How to use DCI formats 1\_1 and 1\_2 for UL-only (in case of separate DL/UL) TCI state update (beam indication)
  + Note: The agreement implies that DCI formats 1\_1 and 1\_2 can be used for UL-only TCI state update beam indication).
  + FFS: Using DCI format 1\_1 and 1\_2 without DL assignment, and with a new acknowledgment mechanism directly in response to decoding DCI format 1\_1 and 1\_2, e.g., analogous to SPS PDSCH release
* Whether/how to support at least one additional DCI format dedicated for UL-only beam indication (in case of separate DL/UL), including:
  + Whether the format can also be used for DL-only beam indication (in case of separate DL/UL) and joint DL/UL beam indication
  + Whether it is a “brand new” format or based on some extension of the existing DCI formats other than 1\_1 and 1\_2 (e.g. 1\_0, 0\_0, 0\_1, or 0\_2)
    - If UL-related DCI is used, whether it is accompanied with UL grant or not
  + Acknowledgment mechanism

On Rel.17 DCI-based beam indication:

* Regarding application time of the beam indication: if beam indication is received, down-select from the following:
  + Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication
  + Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication
  + FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y
* FFS: When to apply the minimum indication delay (e.g., when the newly indicated beam is different with the previously indicated beam)

On Rel.17 DCI-based beam indication, the beam application time is to be down-selected or modified from the following:

* Alt1: The beam application time can be configured by the gNB based on UE capability
  + Support a UE capability for the minimum value of beam application time
  + FFS: the exact minimum values of beam application time supported by UE
  + FFS: whether existing UE capability can be reused as this UE capability.
  + FFS: whether different beam application time values are supported for uplink and downlink
  + FFS: whether UE capability needs to be introduced for the maximum value of beam application time
* Alt2: The beam application time is fixed and defined in specification
* Alt3: The beam application time can be configured by the gNB where the minimum value of beam application time is fixed and defined in specification

Consider multi-panel UE, layer 1/2 inter-cell cases, carrier aggregation aspects

On the beam application time for Rel.17 DCI-based beam indication, the beam application time can be configured by the gNB based on UE capability

* Support a UE capability for the minimum value of beam application time
* FFS: the exact minimum values of beam application time supported by UE
* FFS: whether existing UE capability can be reused as this UE capability.
* FFS: whether different beam application time values are supported for uplink and downlink
* FFS: whether UE capability needs to be introduced for the maximum value of beam application time
* FFS: the reference for defining the UE capability (e.g. from DCI reception or ACK transmission)
* FFS: whether a UE is allowed to report more than 1 values in case of MPUE
* FFS: the application time when DCI and applied channel(s) are on different CCs with same/different SCS(s)s

On the Rel.17 DCI-based beam indication, in RAN1#104bis-e, down-select at least one of the following alternatives regarding the support of DCI format(s) for beam indication in addition to the agreed DCI formats 1\_1/1\_2 with DL assignment (in RAN1#103-e):

* Alt0: No additional DCI format is supported
* Alt1: DCI formats 1\_1 and 1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI
  + Support DCI acknowledgment mechanism, e.g. based on SPS PDSCH release, based on triggered SRS, based on DCI indicating SCell dormancy
  + FFS: How to identify DCI formats 1\_1/1\_2 used for beam indication only (not for scheduling a PDSCH reception, not indicating a SPS PDSCH release, or not indicating SCell dormancy), considering impacts on PDCCH coverage and scheduling mechanism
  + FFS: Whether the UE can/shall assume the gNB configured application time is after ACK transmission
* Alt2: Dedicated DCI format other than 1\_1/1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI
  + Support DCI acknowledgment mechanism, e.g. based on SPS PDSCH release, based on triggered SRS, based on DCI indicating SCell dormancy
  + FFS: If the format is based on an existing DCI format, how to identify the DCI format used for beam indication only
  + FFS: Whether the UE can/shall assume the gNB configured application time is after ACK transmission
* Alt3: UL-related DCI formats 0\_1/0\_2 with UL grant, applicable only for UL-only TCI of separate DL/UL TCI

On Rel.17 DCI-based beam indication, regarding application time of the beam indication: if beam indication is successfully received and the newly indicated beam in the beam indication is different from the previously indicated beam, down-select (no later than RAN1#105-e) one from the following. No other alternatives will be considered:

* Alt1: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the DCI with the joint or separate DL/UL beam indication
* Alt2A: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the acknowledgment of the joint or separate DL/UL beam indication
* Alt 2B: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the acknowledgment of the joint or separate DL/UL beam indication, except that the (new) TCI state update can be applied to the PDSCH, if it exists, (scheduled by the beam indication DCI) and corresponding ACK transmission (provided that the time offset between the DCI and the scheduled PDSCH exceed the threshold, analogous to Rel.15/16)
* Alt2C: Support both Alt1 and Alt2A, and introduce a UE capability that indicates the support of Alt1 or Alt2A
* Alt3: the first slot that is at least X1 ms or Y1 symbols after the [first/last] symbol of the DCI with beam indication and X2 ms or Y2 symbols after the [first/last] symbol of the acknowledgment of the beam indication
* FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y

**Issue 4**

* [Issue 4] For Rel.17 NR FeMIMO, on MP-UE assumption to facilitate fast UL panel selection:
  1. The following assumptions are used:
     + In terms of RF functionality, a UE panel comprises a collection of TXRUs that is able to generate one analog beam (one beam may correspond to two antenna ports if dual-polarized array is used)
     + UE panels can constitute the same as well as different number of antenna ports, number of beams, and EIRP
     + No beam correspondence across different UE panels
     + FFS: For each UE panel, it can comprise an independent unit of PC, FFT timing window, and/or TA.
     + FFS: Same or different sets of UE panels can be used for DL reception and UL transmission, respectively
  2. In RAN1#103-e, identify candidate use cases including MPE, and consider remaining aspects if use cases are identified
  3. In RAN1#103-e, identify candidate signaling schemes for the following:
     + NW to MP-UE (taking into account potential extension of the unified TCI framework in issue 1)
     + MP-UE to NW

In Rel-17 enhancement for facilitating fast uplink panel selection, the following use cases are assumed:

* MPE mitigation
* UE power saving
* UL interference management
* Support different configurations across panels
* UL mTRP

In Rel-17 enhancement on MP-UE to facilitate fast UL panel selection and MPE mitigation, UL Tx panel(s) are assumed to be a same set or subset of DL Rx panel(s)

In Rel.17 enhancement for facilitating fast uplink panel selection, UE-initiated UL panel selection/activation are supported:

* FFS: Whether NW-initiated panel selection/activation is also supported
* FFS: Whether specification support for this feature is necessary and if so the details of such spec support.

**Conclusion**: On Rel.17 enhancements to facilitate UL beam selection for MP-UE, the following terms are used at least for the purpose of discussion:

* ‘Panel activation’ (at least for DL/UL measurement): activating L out of P available UE panel(s) at least for the purpose of DL and UL beam measurements (e.g. reception of DL measurement RS, transmission of SRS)
* ‘Panel selection’ (for UL transmission): selecting 1 out of L activated UE panel(s) for the purpose of UL transmission
* Note: UE-initiated panel activation and selection have been agreed in RAN1#103-e

On Rel.17 enhancement for facilitating fast uplink panel selection,

* Rel.17 TCI state update (based on MAC CE + DCI along with the necessary TCI state activation, or MAC CE only) can be used for UE UL panel selection
* FFS: Whether specification support for this feature is necessary and if so the details of such spec support, e.g.
  + Additional spec support in TCI state definition to accommodate UL panel
  + UE reporting to facilitate UL panel selection
  + UE reporting, e.g. panel-specific report, including UE-panel state, e.g. inactive, active for DL/UL measurement, active for DL reception only, active for UL transmission, or other combination(s) of UE-panel states
  + Support for linking or association of UE panels with CSI-RS/SSB resources or resource sets, SRS resource sets, and/or PUCCH resource groups, etc.

On Rel.17 enhancement for facilitating fast uplink panel selection, for discussion purpose, a panel entity corresponds to one or more RS resources:

* For CSI/beam reporting, the RS resource is an RS associated with measurement and/or reporting
* For beam indication, the RS resource is a source RS for UL TX spatial filter information
* Note: For one RS resource, the corresponding panel entity may vary and is controlled by the UE, and whether/how to maintain a common understanding between gNB and UE can be further discussed/decided
* Note: The above does not preclude possibility that an RS resource can be mapped to multiple panels
* Note: The one or more RS resources may correspond to one or more RS resource set(s) depending on further discussion/decision
* Note: Specification should not be designed in such a way that the UE is required to disclose its antenna implementation

**Issue 5**

* [Issue 5] For Rel.17 NR FeMIMO, on MPE mitigation (that is, minimizing the UL coverage loss due to the UE having to meet the MPE regulation), in RAN1#103-e:
  1. If needed, identify candidate solutions to be down-selected in future meeting(s). The following sub-categories can be used:
     + CAT0. The need for specification support for MPE event detection and, if needed, candidate solutions
     + CAT1. The need for UE reporting associated with an MPE and/or a potential/anticipated MPE event if the UE selects a certain UL spatial resource, e.g., corresponding to DL or UL RS
     + CAT2. The need for NW signaling in response to the reported MPE event (taking into account issue 1) and UE behavior after receiving the NW signaling
     + Note: RAN4 has agreed to specify P-MPR reporting (cf. CRs for TS 38.101/102/133) which can be used as a baseline scheme for further enhancement
     + Note: This may be related to outcome of issue 4b)
  2. Companies are encouraged to submit evaluation results based on the agreed EVM to justify the benefits of the candidate solutions

On UE reporting for MPE mitigation for Rel-17, investigate and, if needed, specify the following:

* Reporting of P-MPR report based on Rel.16 framework.
  + FFS: Whether panel/beam level based P-MPR report is supported
  + FFS: Maximum reported number of panels, e.g. single or multiple
* Reporting SSBRI(s)/CRI(s) and/or indication of panel selection for the purpose of indicating:
  + Alt1: alternative UE panel(s) or TX beam(s) for UL transmission
  + Alt2: feasible UE panel(s) or TX beam(s) for UL transmission taking the MPE effect into account
  + FFS: indication of panel selection details (e.g. explicit/implicit)
* Any additional reporting content: down-select from the following in RAN1#104-e
  + Alt0: no additional reporting content
  + Alt1: Additional reporting content is included (for example P-MPR + L1-RSRP, virtual PHR + L1-RSRP, L1-RSRP/SINR with and without MPE effect, virtual PHR, P-MPR or virtual PHR + CRI/SSBRI, estimated max UL RSRP)
    - Note: Other options are not precluded
    - FFS: Whether the above reporting is triggered by UE or configured by NW

On Rel.17 enhancements to facilitate MPE mitigation,

* On further enhancing the P-MPR report in Rel.16 (already agreed RAN4 framework, including triggering), down select between beam-level and panel-select reporting
* On SSBRI(s)/CRI(s) and/or indication of panel selection, focus study on the following:
  + Reporting of at least SSBRI(s)/CRI(s) to indicate gNB beam(s) that is feasible for UL transmission: additional reporting quantities are FFS
  + Reporting of at least an indicator associated with a UE ‘panel’ that is feasible for UL transmission: additional reporting quantities are FFS
* Note: Just as agreed in RAN1#103-e, the purpose is to assess whether specification is needed or not

On Rel.17 enhancements to facilitate MPE mitigation, decide in RAN1#104bis-e whether to support at least one the following (not necessarily, but can be, in one reporting instance):

* {Rel.16 P-MPR based (beam/panel-level)} + {A}, where A is either Opt1A, Opt1B, Opt1C, or Opt1D:
  + Option 1A: Virtual PHR or a modified version associated with each activated UL TCI or, if applicable, joint TCI
  + Option 1B: {SSBRI(s)/CRI(s) and/or panel indication}
  + Option 1C: {SSBRI(s)/CRI(s) and/or panel indication} + virtual PHR or a modified version associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured)
  + Option 1D: No additional reporting quantity
* {SSBRI(s)/CRI(s) and/or panel indication} + {A}, where A is either Opt2A, Opt2B, Opt2A+ Opt2B, or Option 2C
  + Option 2A: 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: How panel-level L1-RSRP [L1-SINR] is reported if L1-RSRP [L1-SINR] is associated with panel
    - FFS: Whether/how to account for MPE effect in L1-RSRP [L1-SINR] report, e.g. by using scaled L1-RSRP [L1-SINR]
    - FFS: Whether/how to enhance existing beam reporting format to support Option 2A
  + Option 2B: Virtual PHR or a modified version associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured)
  + Option 2C: No additional reporting quantity

**Issue 6**

On Rel.17 enhancements based on the unified TCI framework, perform study and, if needed, specify the following:

* Group1: Beam management with reduced DL signaling to reduce latency
* Group2: Reducing activation delay of TCI states and PL-RSs (including other WGs, e.g. RAN4)
  + On RAN4-related matters, assessment/study phase can be done in RAN1. If RAN4-based enhancements are found necessary, a LS to RAN4 will be sent (to prepare RAN4 work)

Note: Given its dependence on the maturity compared to other issues (1 to 5), when to start the work and how much work is done on issue 6 should depend on the progress on the other issues.

# References

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | [R1-2102333](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102333.zip) | Enhancements on multi-beam operation | Huawei, HiSilicon |
| 2 | R1-2102378 | Enhancements on Multi-beam Operation | OPPO |
| 3 | [R1-2102432](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102432.zip) | Remaining Issues on Multi-beam Operation | InterDigital, Inc. |
| 4 | R1-2102441 | Enhancements on Multi-beam Operation | Spreadtrum Communications |
| 5 | [R1-2102506](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102506.zip) | Further discussion on multi beam enhancement | vivo |
| 6 | R1-2102598 | Discussions on enhancements on multi-beam operation | CATT |
| 7 | [R1-2102660](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102660.zip) | Enhancements on Multi-beam Operation | ZTE |
| 8 | R1-2102675 | Enhancement on multi-beam operation | MediaTek Inc. |
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| 10 | R1-2102725 | Discussion on Enhancements for Multi-beam Operation | Asia Pacific Telecom, FGI |
| 11 | [R1-2102767](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102767.zip) | Enhancement on multi-beam operation | FUTUREWEI |
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| 13 | [R1-2102838](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102838.zip) | Enhancements on Multi-beam Operation | Lenovo, Motorola Mobility |
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| 15 | [R1-2102954](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102954.zip) | Enhancements on Multi-beam Operation | Ericsson |
| 16 | [R1-2102959](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2102959.zip) | Enhancements on multi-beam operation | Xiaomi |
| 17 | R1-2103014 | Enhancements to Multi-Beam Operations | Intel Corporation |
| 18 | [R1-2103088](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103088.zip) | Views on Rel-17 Beam Management enhancement | Apple |
| 19 | R1-2103150 | Enhancements on Multi-beam Operation | Qualcomm Incorporated |
| 20 | [R1-2103221](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103221.zip) | Multi-Beam Enhancements | Samsung |
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