**3GPP TSG RAN WG1 #104-e R1-2101185**

**e-Meeting, January 25th – February 5th, 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:

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

## Issue Categorization (from RAN1#102-e)

Issues raised by interested companies are organized as follows to identify pertinent aspects (including design components). This is not intended to be an exhaustive list of alternatives, but rather a skeleton to facilitate planning and progress tracking from meeting to meeting. The details on each item will be hashed out as the work progresses.

Table 1 Category of issues

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| 1. **Unified TCI framework** – by means of extending the Rel.15/16 DL TCI framework (e.g. TCI state definition)    1. Design for UL common TCI       1. Goal: utilize same unified design as DL TCI, specify UL TCI framework to facilitate common TCI state update for UL (data, PUCCH, SRS)       2. Including UL PC, timing control, PL RS, and/or default UL common beam    2. Design for DL common TCI       1. Goal: identify and, if needed, specify potential refinement on Rel.15/16 DL TCI framework to facilitate common TCI state update for DL (data and DL assignment of the same UE)       2. Including default DL common beam    3. Additional QCL Type-D relations for TCI state definition       1. Goal: if supported, facilitate extended use of DL RS (e.g. SSB, CSI-RS) for UL and UL RS (e.g. SRS) for DL    4. Facilitating combined/joint and separate TCI for DL and UL:       1. Goal 1: when beam correspondence is assumed (common scenario), specify TCI framework to facilitate common TCI state update for DL and UL       2. Goal 2: when beam correspondence is not assumed (e.g. MPE event), facilitate separate TCI state updates for DL and UL   *Note: the following factors should be considered in the above design aspects*   * + - *CA and cross-carrier scheduling operation (e.g. inter- and intra-band CA, FR1/FR2 CCS)*     - *Beam correspondence assumption*     - *When applicable, performance assessment based on the agreed EVM*  1. **L1/L2-centric inter-cell mobility**     1. The need for and/or the applicability and scope of L1-/L2-centric inter-cell mobility:       1. Goal: assess the need for and/or the applicability (use cases) and scope of L1/L2-centric inter-cell mobility (as an enhancement on the Rel.15/16 L3-based approach)    2. Method of enabling L1/L2-based inter-cell mobility:       1. Goal: select the type of information pertinent to non-serving cell(s) in TCI state to facilitate inter-cell mobility operation, e.g. PCI, SSB/TRS indicator TAGs, L1-RSRP report for RS in a neighboring cell   *Note: the following factors should be considered in the above design aspects*   * + - *CA and cross-carrier scheduling operation (e.g. inter- and intra-band CA, FR1/FR2 CCS)*     - *Beam correspondence assumption*     - *When applicable, performance assessment based on the agreed EVM*  1. **Dynamic TCI state update signaling medium** for common TCI state update operation    1. Signaling medium: L1 control signaling (DCI-based on PDCCH) and/or MAC CE       1. Goal: select the medium and the associated detailed design used for signaling TCI state update       2. This includes DCI format when applicable, reliability (HARQ-ACK and/or repetition), UE-specific vs. UE-group, 1-part vs. 2-part signaling, timing aspect    2. Exact content:       1. Goal: define list of parameters included in the TCI state update (supporting multiple formats is possible)       2. This includes (a) separate DL and UL (DL-only and UL-only), (b) Combined joint DL and UL   *Note: the following factors should be considered in the above design aspects*   * + - *CA and cross-carrier scheduling operation (e.g. inter- and intra-band CA, FR1/FR2 CCS)*     - *Beam correspondence assumption*     - *When applicable, performance assessment based on the agreed EVM at high-speed scenarios*  1. **Extension of UL TCI for UE with (capable of) multiple panels** to facilitate UL fast panel selection, given the unified TCI framework design (cf. the above aspect 1 and 3)    1. Mechanism to identify a UE panel:       1. Goal: Assess whether resource ID or resource set ID (SRS, CSI-RS, ...) is sufficient or an explicit (new) panel ID is needed    2. Signaling mechanism to enable UL fast panel selection,       1. Goal 1: assess needed signaling from UE to NW, e.g. to indicate multi-panel capability, UE reporting       2. Goal 2: extending UL TCI state update mechanism for various scenarios for UL fast panel selection, e.g. if supported, DL and UL TCI state update are (a) common, (b) separate;    3. The need for panel-specific timing and power control enhancements in relation to panel indication and unified TCI framework design       1. Goal: assess the need for panel-specific timing and power control and, if needed, the associated specification features   *Note: the following factors should be considered in the above design aspects*   * + - *CA and cross-carrier scheduling operation (e.g. inter- and intra-band CA, FR1/FR2 CCS)*     - *The use of UE panels for both DL reception and UL transmission, including the need for UE reporting and NW signaling*     - *Beam correspondence assumption*  1. **MPE mitigation -** given the unified TCI framework design and multi-panel UE support (cf. the above aspect 1, 3, and 4)    1. The need for enhancement(s) to reduce UL coverage loss due to meeting MPE regulation       1. Goal: assess the need based on a list of candidate schemes    2. Method of enabling MPE mitigation:       1. Goal: scheme selection for MPE mitigation   *Note: the following factors should be considered in the above design aspects*   * + - *Beam correspondence assumption*     - *Performance assessment based on the agreed EVM*     - *Support for fast panel selection on MP-UE*  1. **Advanced beam refinement and tracking** targeting high-mobility and large number of configured TCI states **-** given the unified TCI framework design for intra- and L1/L2-centric inter-cell mobility, and multi-panel UE support (cf. the above aspect 1, 2, 3, and 4)    1. Overhead and latency reduction of beam refinement       1. Goal: evaluate and select schemes (including NW signaling and configuration as well as UE signaling) to enable faster gNB/UE beam refinement       2. Refinement is understood as selecting narrower (more spatially precise) beam from a set of candidate beams (gNB and/or UE beams, jointly or separately) which also includes beam sweeping    2. Overhead and latency reduction of beam tracking       1. Goal: evaluate and select schemes (including NW signaling and configuration as well as UE signaling) to enable faster gNB and/or UE beam tracking       2. Tracking is understood as prompt/predictive response to the change in propagation link   *Note: the following factors should be considered in the above design aspects*   * + - *CA and cross-carrier scheduling operation (e.g. inter- and intra-band CA, FR1/FR2 CCS)*     - *Beam correspondence assumption*     - *Performance assessment based on the agreed EVM* |

## Summary of companies’ inputs based on the issue category in Table 1

The summary is based on the issue categorization in Table 1. The listed issues are structured primarily to facilitate some progress on pending issues identified in the agreements made in RAN1#103-e and 104-e (see Appendix A).

### Issue 1 (Rel.17 unified TCI framework)

Table 2 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 1.1 | Source RS type for DL QCL (Type D, for DL RX spatial filter reference) information for DL common UE-dedicated reception on PDSCH and all/subset of CORESETs | CSI-RS for BM (\*)   * **Yes:** Ericsson, Huawei/HiSi, Samsung, Qualcomm, Intel, MTK, Apple, vivo, Lenovo/MoM, Xiaomi, Sony, Spreadtrum, CATT, Convida, NTT Docomo, ZTE, OPPO, Nokia/NSB, Futurewei * **No:**   CSI-RS for tracking (\*)   * **Yes:** Ericsson, Samsung, Qualcomm, MTK, Apple, vivo, Lenovo/MoM, Xiaomi, Sony, Spreadtrum, CATT, Convida, NTT Docomo, ZTE, OPPO, Nokia/NSB, Futurewei, Huawei/HiSi * **No:**   SSB   * **Yes:** Ericsson, Samsung, Qualcomm, Intel, vivo, Lenovo/MoM, Xiaomi, CATT, Convida, ZTE, Nokia/NSB * **No:** Huawei/HiSi, MTK, Apple, Futurewei   CSI-RS for CSI   * **Yes:** Apple, Sony, ZTE, Huawei/HiSi * **No:** MTK, Nokia/NSB, Futurewei   SRS for BM   * **Yes:** IDC, Spreadtrum, Nokia/NSB, Apple (with periodic DL RS), ZTE (also need support for SRS beam sweeping), Convida, Samsung, vivo, Lenovo/MoM, Xiaomi, CATT * **No:** Huawei/HiSi, Ericsson, Intel, Sony, OPPO, Futurewei (need further study), LG | (\*) Note that the following is supported as QCL Type-D source RS for PDSCH and PDCCH in Rel.15/16:   * CSI-RS for BM * CSI-RS for tracking   (\*\*) Note that the following is supported as QCL Type-D source RS for PDSCH in Rel.15/16:   * CSI-RS for CSI |
| 1.2 | Additional source RS type for UL TX spatial filter  Note: SSB and CSI-RS for BM have been agreed | CSI-RS for tracking   * **Yes:** Ericsson, MTK, Apple, Lenovo/MoM, Xiaomi, Spreadtrum, Samsung, CATT, ZTE, Nokia/NSB, Futurewei, Huawei/HiSi * **No:**   Non-BM CSI-RS other than for tracking   * **Yes:** Sony, ZTE, Huawei/HiSi * **No:** Apple, Qualcomm OPPO, Nokia/NSB, Futurewei, IDC   Non-BM SRS   * **Yes:** Sony, Spreadtrum, ZTE, Huawei/HiSi * **No:** Apple, Qualcomm OPPO, Futurewei, IDC |  |
| 1.3 | Supported QCL types | DL large scale properties inferred from one (qcl-Type1) or two RSs (qcl-Type1 and qcl-Type2) analogous to Rel.15/16:   * **Yes**: Ericsson, MTK, Samsung, OPPO, Qualcomm, Intel, Apple, vivo, Lenovo/MoM, Xiaomi, Sony, Spreadtrum, Convida, NTT Docomo, ZTE, Nokia/NSB, Huawei/HiSi, IDC * **No**:   DL TCI state for separate DL/UL TCI is always configured with 2 source RSs:   * **Yes**: CMCC * **No**: Apple, Sony, Spreadtrum, ZTE, Ericsson OPPO, Huawei/HiSi   UL spatial filter derived from one RS of QCL Type D:   * **Yes**: Ericsson, Convida, MTK, Samsung, Qualcomm, Intel, Apple, vivo, Lenovo/MoM, Xiaomi, Sony, Spreadtrum, NTT Docomo, ZTE OPPO, Nokia/NSB, Futurewei, Huawei/HiSi (if this is for joint DL/UL TCI) * **No**: |  |
| 1.4 | Additional applicability of the common DL QCL information  Note: UE-dedicated reception on PDSCH and all/subset of CORESETs have been agreed | CSI-RS resource for CSI:   * **Yes**: OPPO, Spreadtrum, Ericsson, vivo, MTK, AT&T, Convida, Samsung, Qualcomm, Lenovo/MoM, Xiaomi, Sony, CATT, NTT Docomo, ZTE (AP-CSI-RS for CSI only), Nokia/NSB, APT * **No**: Apple, Huawei/HiSi, Futurewei (need further discussion)   Some CSI-RS resource(s) for BM:   * **Yes**: OPPO (some), Ericsson (all), AT&T(some), Samsung (some), Qualcomm, Xiaomi(some), Sony, CATT, Convida, NTT Docomo ZTE (AP-CS-RS for BM only) , Nokia/NSB, APT (for CSI-RS-BM with repetition “on”) * **No**: Huawei/HiSi, vivo, Apple, Futurewei (need further discussion, depending on whether the resource is repeated or not)   CSI-RS for tracking:   * **Yes**: Spreadtrum, AT&T, Qualcomm, Sony, Ericsson (aperiodic), Nokia/NSB, APT * **No**: Huawei/HiSi, Apple, MTK, vivo, ZTE, Ericsson (periodic) OPPO, Futurewei |  |
| 1.5 | Additional applicability of the common UL TX spatial filter reference to SRS | Some SRS (resource set(s)) for BM:   * **Yes**: OPPO, Samsung, Sony, CATT, ZTE (also need support for SRS beam sweeping) * **No**: Huawei/HiSi, APT, Qualcomm, MTK, vivo, Spreadtrum, Convida, Futurewei (need further discussion) | Note: SRS for CB/NCB/antenna switching is already agreed as optional |
| 1.6 | PL-RS in relation to UL TCI state and channels | Alternatives:   * **PL-RS included in UL TCI state:** IDC, Ericsson (optional for DL RS), Apple (only valid when SRS is configured for beam indication), vivo (in case of DL RS in TCI state), MTK (for no PL-RS configured, and DL CSI-RS or SSB), Intel, AT&T, OPPO (separate RS), Fraunhofer IIS/HHI (separate RS), Qualcomm, Lenovo/MoM, Xiaomi, NTT Docomo, OPPO, Nokia/NSB (QCL-TypeD RS if periodic and no PL-RS configured /associated), LG * **PL-RS associated with UL TCI state:** Futurewei, Spreadtrum, Nokia/NSB, Huawei/HiSi, MTK, Sony, Qualcomm (separate field in the same DCI), CATT, NTT Docomo, ZTE, CMCC * **PL-RS not associated with UL TCI state:** Ericsson (in case of UL RS in TCI state) * **Use Rel-16 PL-RS framework:** vivo (for UL RS in TCI state)   MAC CE configures association between activated TCI states and PL-RS/PC: CATT, MTK(PL-RS only), Sony(only PL-RS) |  |
| 1.7 | UL parameters (PC, other than PL-RS) in relation to UL TCI state and channels | Alternatives:   * **Other UL parameters included in UL TCI state:** ID, Apple, LGE, Intel * **Other UL parameters associated with UL TCI state:** Nokia/NSB, ZTE, Samsung, CATT, Lenovo/MoM * **Other UL parameters associated with channel and UL TCI state:** Nokia/NSB, ZTE, Sony, Samsung, Qualcomm, Spreadtrum, ZTE, OPPO (not for SRS), Futurewei, NTT Docomo * **Other UL parameters not associated with UL TCI state:** Ericsson, Huawei/HiSi, vivo, MTK, Fraunhofer IIS/HHI OPPO (this option is for SRS only) * **Use Rel-16 framework:** CMCC, MTK   MAC CE configures association between activated TCI states and PL-RS/PC: CATT |  |
| 1.8 | Maximum value of M (DL) and N (UL) | **Max=1 for sTRP**: OPPO, Spreadtrum, ZTE, MTK, Convida, Samsung, Lenovo/MoM, Sony, CATT, Fraunhofer IIS/HHI, Ericsson, IDC  **Max M=2 for mTRP**: Nokia/NSB, Samsung, APT, AT&T, Sony, CATT, NTT Docomo (but, prefer to prioritize discussion for S-TRP first), IDC  **Max M>1 and N>1**: Futurewei, Qualcomm, vivo, Xiaomi, Huawei/HiSi, LG |  |
| 1.9 | TCI state applicability to a subset of DL channels or CORESETs (in addition to all CORESETs) | **Yes**: LGE, Nokia/NSB, Qualcomm, Intel (if new DCI is used), vivo, Lenovo/MoM, Xiaomi, CATT, Futurewei, Huawei/HiSi, APT  **No, at least for M=N=1 (applies to all UE specific channels)**: OPPO, Samsung, Intel (for existing DCI formats), MTK, Sony, NTT Docomo, ZTE, Ericsson, IDC |  |
| 1.10 | TCI state applicability to a subset of UL channels or PUCCHs (in addition to all PUCCHs) | **Yes**: LGE, Nokia/NSB, Qualcomm, Intel (per PUCCH group), vivo, Lenovo/MoM, Xiaomi, CATT, Futurewei, Huawei/HiSi (TDMed, not STxMP), APT  **No, at least for M=N=1** (applies to all UE specific channels): OPPO, Samsung, MTK, Sony, NTT Docomo, ZTE, Ericsson |  |
| 1.11 | TCI State pool for CA  Alt1: Shared among CCs  Alt2: Individually configured per CC | **Alt1**: Spreadtrum, Xiaomi, ZTE, vivo, MTK, Intel, Sony, NTT Docomo, Samsung, Qualcomm, Lenovo/MoM, Ericsson (UL TCI), IDC  **Alt2**: OPPO, Nokia/NSB, CMCC, Huawei/HiSi, CATT, APT, TCL, Ericsson (DL TCI), Futurewei, LG  **QCL Type-A implicitly determined based on CC:** Intel, Samsung, MTK, CATT, ZTE |  |
| 1.12 | For separate TCI, UL TCI state pool  Alt1: Shared pool with joint/DL TCI state  Alt2: Separate pool | **Alt1**: Spreadtrum, Xiaomi, ZTE, CATT, vivo, MTK, Intel, Convida, Qualcomm, Samsung, CATT, NTT Docomo  **Alt2**: Futurewei, OPPO, Lenovo/MoM, Nokia/NSB, CMCC, Ericsson, Huawei/HiSi, AT&T, Sony, Lenovo/MoM, APT |  |
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Re issue 1.1 and 1.3, the following DL QCL configurations are supported in Rel.15/16 (cf. R1-1808001 section 7.1.2.3.7):

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| For the next two tables, if QCL type-D is applicable, DL RS2 and QCL type-2 shall be configured for the UE except for the default case (fourth row in the two tables below). If TRS for downlink is used for QCL type-D, the TRS must have an SSB or CSI-RS for BM as source RS for QCL type-D.  For the DM-RS of PDCCH, the UE should only expect the following three configurations of the higher layer parameter *TCI-State* while the fourth configuration is valid as default, before TRS is configured:   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Valid TCI state Configuration** | **DL RS 1** | ***qcl-Type1*** | **DL RS 2 (if configured)** | ***qcl-Type2* (if configured)** | | 1 | TRS | QCL-TypeA | TRS | QCL-TypeD | | 2 | TRS | QCL-TypeA | CSI-RS (BM) | QCL-TypeD | | 3\*\* | CSI-RS (CSI) | QCL-TypeA |  |  | | 4\* | SS/PBCH Block\* | QCL-TypeA | SS/PBCH Block\* | QCL-TypeD |   \* Before TRS configured. Note: this is not a TCI state, rather a valid QCL assumption  \*\*Note: Only when QCL type-D is not applicable  For the DM-RS of PDSCH, the UE should only expect the three following configurations of the higher layer parameter *TCI-State* while the fourth is valid by default, before TRS is configured:   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Valid TCI state Configuration** | **DL RS 1** | ***qcl-Type1*** | **DL RS 2 (if configured)** | ***qcl-Type2* (if configured)** | | 1 | TRS | QCL-TypeA | TRS | QCL-TypeD | | 2 | TRS | QCL-TypeA | CSI-RS (BM) | QCL-TypeD | | 3\*\* | CSI-RS (CSI) | QCL-TypeA | CSI-RS (CSI) | QCL-TypeD | | 4\* | SS/PBCH Block\* | QCL-TypeA | SS/PBCH Block\* | QCL-TypeD |   \* Before TRS configured. Note: this is not a TCI state, rather a valid QCL assumption  \*\* Note: QCL parameters may not be derived directly from CSI-RS (CSI) |

**Proposal 1.1**: 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 common 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 common UL TX spatial filter at least for dynamic-grant/configured-grant based PUSCH, 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 is 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 one of the M DL TCIs provides common QCL information at least for one of the M beam pair links for UE-dedicated receptions on PDSCH and subset of CORESETs in a CC

For N>1:

* UL TCI: Each of the N source reference signals in one of the N UL TCIs provide a reference for determining common UL TX spatial filter at least for one of the N dynamic-grant(s)/configured-grant(s) based PUSCH, 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 is 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.

**Proposal 1.2**: On Rel.17 unified TCI framework, down select or modify by RAN1#104bis-e from the following alternatives:

* Alt1. A UE can be dynamically (i.e. within the beam indication signaling via DCI) switched between joint DL/UL TCI and separate DL//UL TCI, if UE is capable of both joint DL/UL TCI and separate DL/UL TCI.
  + Details are FFS.
* Alt2. A UE can be configured with either joint DL/UL TCI or separate DL/UL TCI 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

**Proposal 1.3**: 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 common 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

**Proposal 1.4**: 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

**Proposal 1.5**: On the QCL types for Rel.17 unified TCI framework:

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

Table 3 Additional inputs: issue 1

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| --- | --- |
| **Company** | **Input** |
| Qualcomm | Not support Proposal 1.1. Instead, M>1 and N>1 should be supported. To our understanding, M=N=1 means a single active common beam for all channels. It may not be suitable for all scenarios especially when beam blocking is likely to happen and high reliability is required. In this case, 2 active common beams for different subsets of channels can provide much better reliability even in case of single TRP, especially when UE already supports multiple active TCI states.  {see Moderator input}  For Proposal 1.2, we slightly prefer no support. Suppose there are 2 active common beams but 2nd common beam now suffers from MPE issue for the corresponding UL beam. Then the 2nd common beam can be replaced by a separate DL beam plus a separate UL beam not suffering MPE. Therefore, configuring both joint and separate TCI states can provide better flexibility to achieve the same reliability. No need to have config restriction. |
| Intel | We have provided additional feedback in Table 2, but have some questions for clarification:   * Issue 1.3: For the UL spatial filter, is this for joint TCI state or separate UL TCI state? * Issue 1.4, 1.9, 1.10: We would like to clarify the signaling mechanism assumed here – Is this for TCI indication using current DCI formats? If yes, then support of subset of DL channels or selective applicability to a subset of reference signal may not be feasible (or require significant additions to DCI). Additionally, it should be clarified which options require higher layer signaling in addition to dynamic indication   {Mod: Re issue 1.3, it starts with UL-only. For joint, the applicable QCL will be what’s common between DL and UL. Re issue 1.4,9,10, yes it is based on the same TCI state update as what we have been discussing}  For Proposal 1.1, the definitions for DL and UL TCI are not clear to us. Is it the intention to define the functionality of what a TCI state is? Based on Rel15/16 definition, TCI state should convey QCL info where QCL Type A is mandatory and QCL Type D is optional. In the proposal, it is not clear what “provides common QCL information” means and why only QCL Type D is mentioned.  {see Moderator input}  For Proposal 1.2, we are not in favor of imposing this restriction before the signaling design is agreed. There may be use cases like HetNet which supports UL reception (DL on macro), where separate beam indication may be desired and when TCI states share a common pool, it may be up to the network to activate certain combination of TCI states using MAC-CE. In this regard activation of appropriate TCI state using DCI can implicitly indicate the joint or separate beam indication. |
| Samsung | We support proposal 1. We can add the following:  • Joint DL/UL TCI: When configured, a common (therefore, joint) TCI is shared by the above DL TCI and UL TCI. Source reference signal of QCL-TypeD for DL TX spatial filter, is also a reference signal for determining the common UL TX spatial filter.  For proposal 2, we would like to include MAC CE signaling as an additional method for updating the configuration of joint or separate DL/UL TCI. If UE switches between detecting and non-detecting an MPE event, it would be good to switch between joint and separate TCI state configuration without involving the RRC. We proposal the following update:  **Proposal 1.2:** On Rel.17 unified TCI framework, a UE can be configured with either joint DL/UL TCI or separate DL/UL TCI via higher-layer (RRC) signaling or MAC CE signaling. |
| MediaTek | For Proposal 1.1, support in principle. In our understanding, this proposal doesn’t mean to preclude M>1and/or N>1, and it just clearly defines how to apply common QCL information and/or common UL TX spatial filter for joint/separate DL/UL TCI update if M=N=1. Basically, all of the listed items are already agreed in the previous meeting. However, for the case if M>1and/or N>1, how to apply common QCL information and/or common UL TX spatial filter for joint/separate DL/UL TCI update has to be further discussed, and a different proposal for M>1 and/or N>1 may be needed.  One question for clarification on Proposal 1.1. If M=N=1, is it still possible to apply common QCL on only a subset of control channels instead of all?  {Mod: With M=N=1, the baseline is ‘all’ unless there is a reason to do otherwise. This should be discussed.}  No support Proposal 1.2. Semi-statically configuring either joint update or separate update is not preferred. In the last meeting, RAN1 reached agreements on UE-initiated UL panel selection/activation and the active UL panel(s) may not be fully aligned with active DL panel(s). The UL panel selection/activation could done in dynamic for different purposes. According to L1 reporting from UE, NW will need the flexibility to dynamic switch between joint and separate DL/UL TCI updates to accommodate the case if the feasible UL beam pair link(s) is not aligned with the feasible DL beam pair link(s). |
| Apple | We provided our views in the Table above.  For Proposal 1.1, is it correct understanding that has already been agreed?  {See Moderator input}  For Proposal 1.2, I am not sure whether any signaling is needed. What would be the problem if the MAC CE activates the following code point?   * Codepoint 1: DL TCI 1, UL TCI 2 * Codepoint 2: DL TCI 2 * Codepoint 3: UL TCI 1 * Codepoint 4: joint UL/DL TCI 3 |
| vivo | We provided some of our preferences in summary of issue 1.  For proposal 1.1, we have similar understanding as Qualcomm that M>1, N>1 should not be FFS.  For proposal 1.2, we share similar understanding as Samsung and Apple that MAC CE or DCI may also be used. Before we decide how the TCI state is indicated, this may not be touched. |
| Lenovo/MoM | Proposal 1.1: Support. We understand this is on the definition of DL/UL TCI and not on the value of M and N. This does not exclude M>1 or N>1.  Proposal 1.2: Support. |
| Xiaomi | For proposal 1.1, we support it in principle. And we think it has already been agreed. We also think that M>a and/ or N>1 should be supported. But for M> 1 and/ or N>1, how to apply the common information may be different.  For Proposal 1.2, we slightly prefer no support. We would like to include MAC CE and DCI as an explicit and / or implicit signaling. |
| Sony | We provided our additional preference in the table above.  To proposal 1.1, we are supportive.  As for proposal 1.2, there might be cases that a UE configured only with joint TCI experiences MPE issue, so the UE would have to use a separate UL beam. Shall we suggest to slightly change the wording at the early stage as follows  **Proposal 1.2**: On Rel.17 unified TCI framework, a UE can be configured with ~~either~~ joint DL/UL TCI and/or separate DL/UL TCI via higher-layer (RRC) signaling. |
| Spreadtrum | Support Proposal 1.1 in principle. Besides, for M=N=1 case, some channels/RSs can be configured based on R15/R16 TCI framework.  For Proposal 1.2, we would like to add MAC CE signaling for switching between joint and separate UL/DL TCI indication modes. |
| Moderator | Re proposal 1.1, the purpose is to ensure all companies are on the same page because there was some confusion in the last meeting especially on what joint TCI means and subset vs. all CORESETs (Intel attempted to clarify along the same line when discussing the text for our first agreement on issue 3 but was later removed). For that, I reuse the wording from the previous agreements as much as possible.  I will reword the definition for M=N=1 once I receive more comments (next revision).  I will also add similar wording for N>1 and/or N>1 (several options) to avoid misunderstanding. The intention was not to deprioritize this case.  Re proposal 1.2, three alternatives for down selecting are given. |
| CATT | Proposal 1.1: Support.  Proposal 1.2: Support. For the first sentence of alt-1, we are also OK not to mandate UE to always support joint DL/UL. UE may report whether it supports joint DL/UL or separate DL/UL. NW can activate suitable TCI-states that match UE’s capability.  Proposal 1.3, 1.4, 1.5 are OK to us. |
| Convida Wireless | OK with the FL proposals. |
| NTT Docomo | Proposal 1.1: Support in principle. Question: In DL TCI, proposal only mentions “one for QCL-TypeD”. We are wondering why not mentioning “one for QCL-TypeA” as well? The applied channels are PDSCH/PDCCH, QCL type A should be covered in the proposal.  {Mod: Added “if configured” for Type D following Rel.15/16, i.e. Type A is in qcl-Type1 by default, while Type D needs to be configured for qcl\_Type2 – please see above table citing the Rel.15 agreement}  Proposal 1.2, 1.3, 1.4, 1.5: Support. |
| Fraunhofer IIS/HHI | Some of our views have been updated in the table. For the TCI state pools to be used, we are generally ok with either the joint or separate pools being used for separate TCI indication with a slight preference towards separate pools along with PL RS indication.  Proposal 1.1: Agree in principle.  Proposal 1.2: Support the proposal. Our preference is Alt-1.  Proposal 1.3: Support |
| ZTE | Regarding proposal 1.1, we are fine in principle. The one ambiguity part is “when configured”: does it mean that it is drafted from the perspective of RRC level? It seems to be relevant to discussion about common/separate TCI pool(s). To make it general, we have the following suggestions   * Joint DL/UL TCI: When indicated, a common (therefore, joint) TCI is shared by the above DL TCI and UL TCI. * Separate DL/UL TCI: When indicated, the above DL TCI and UL TCI are distinct (therefore, separate).   {Mod: Good point, “When configured” is removed for now before proposal 1.2 undergoes down selection process}  Regarding proposals 1.2, 1.3, 1.4 and 1.5, we support all of them. |
| Ericsson | Proposal 1.1: Support  Proposal 1.2: Support. Alt-2 and Alt-3 would seem to be subsets of Alt-1  Proposal 1.3: In Rel-15, there are a set of QCL relations that are supported for various target RSs. Rather than agreeing on RSs individually, could we state that the allowed source/target QCL relations in 38.214 is supported for QCL TypeD?  {Mod: Good point, added, but still keeping the list just to avoid ambiguity}  Proposal 1.4: Support  Proposal 1.5: Propose to clarify: “UL spatial filter is derived from one RS of QCL Type D for joint UL/DL TCI “  {Mod: Yes} |
| OPPO | For proposal 1.1: We do not support M > 1 and N >1. We shall first settle down the design for M = 1 and N =1, then we can consider the case such as mTRP.　And suggest to update the following sub-bullet to:   * Joint DL/UL TCI: When configured, a common (therefore, joint) TCI is shared by the above DL TCI and UL TCI, and the RS configured for QCL-TypeD is also used as PL RS.   {Mod: The PL RS issue still needs to be settled so it can be left for now.}  For proposal 1.2: we do not support to use RRC signaling to configure the mode of joint or separate TCI.  For Proposal 1.5: the following operation shall be only in joint TCI state.   * UL spatial filter is derived from one RS of QCL Type D in joint TCI state   {Mod: Yes} |
| Nokia/NSB | Re proposal 1.1, we do not support current form. It should be amended to include M>1, N>1. We also suggest to capture and confirm that all definitions of TCI state are clarified, so no further type of TCI RAN1 will define, to avoid confusion. For example, we suggest either to add definition of common TCI, or to clarify that it is not a term to be defined/used in further RAN1 discussion.  {Mod: Yes, the term “common TCI” is not needed. This can be clarified.}  Re proposal 1.2: O.K. We support alt. 1  Re proposal 1.3: O.K.  Re proposal 1.4: O.K.  Re proposal 1.5: O.K. |
| Futurewei | Our views are updated in the table above.  Proposal 1.1: Not support. We shared similar view as Qualcomm that M>1 and N>1 should be supported even for the case of single TRP to improve the reliability of PDCCH and to facilitate beam failure detection and recovery, which is discussed in our contribution R1-2100044.  Proposal 1.2: Ok. We support Alt. 1.  Proposal 1.3: Support the proposal.  Proposal 1.4: Support the proposal.  Proposal 1.5: Support the proposal.  On Issue #1.3, regarding the statement “DL TCI state for separate DL/UL TCI is always configured with 2 source RSs”, what does “always” mean here? Is QCL-TypeD always be included in the DL TCI state? Some clarifications are needed. |
| Intel | **Proposal 1.1:**   * For DL TCI, we share similar view as Docomo that QCL Type A should also be covered. * Additionally, for terminology, we have thus far used “joint” for common DL/UL beam indication and “common” for across channels/RS within DL/UL. Therefore, for the 2nd last bullet, we should avoid the word “common” for joint DL/UL TCI. * For separate and joint TCI, we do not think the word configured should be used since it may imply that UE is somehow higher layer configured with joint or separate beam indication. To avoid this we have the following suggestion for wording:   + Joint DL/UL TCI: ~~When configured, a common (therefore, joint)~~ A TCI is shared (therefore, joint) by ~~the above~~ DL ~~TCI~~ and UL ~~TCI~~.   + Separate DL/UL TCI: ~~When configured, the above~~ DL TCI and UL TCI are distinct (therefore, separate).   {Mod: This is clearer, done}  **Proposal 1.2:** We support Alt-1. For Alt-2/3 certain use cases, e.g., UL on HetNet and MPE mitigation may incur larger latency for UL-only beam switching if DCI codepoints only support homogenous TCI states and reconfiguration is needed every time UL beam needs to be independently switched.  **Proposal 1.3:** We are OK to support. We additionally want to clarify why SSB is not included since this is intended for joint indication framework of common beams and SSB is already agreed for UL  {Mod: This will be discussed in later round(s)}  **Proposal 1.4, 1.5:** OK to support |
| Samsung2 | We are OK with the updated proposal 1.1. For M>1 and N> we would like to consider after the design for M=1 and N=1 is stable.  We support proposal 1.2 Alt3.  We are OK with proposal 1.3, we support SSB and SRS for BM are QCL sources for DL QCL Type D.  We are OK with proposal 1.4.  We are OK with proposal 1.5. |
| MediaTek2 | Support proposal 1.1 with Intel, ZTE, and Docomo’s suggestions and some modifications:  **[Proposal 1.1**: 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 discussion and agreement purposes) if M=N=1:   * DL TCI: The source reference signal(s) in the DL TCI provides common QCL information at least for UE-dedicated reception on PDSCH and all or subset of CORESETs in a CC * UL TCI: The source reference signal in the UL TCI provides a reference for determining common UL TX spatial filter at least for dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC * Joint DL/UL TCI: a common (therefore, joint) TCI state is indicated for the above DL TCI and UL TCI. * Separate DL/UL TCI: two distinct (therefore, separate) TCI states, one indicated for the above DL TCI and one indicated for the above UL TCI   {Mod: The intention of joint/separate is on the TCI itself, not simply TCI state (indication). It is understood that TCI state is the ‘state’ (value) of the TCI at a given time.}  Support proposal 1.2 in principle. However, Alt1is not clear for us. Whether Alt1 mean no separate UE capabilities for the support of joint and separate TCI update? We believe even DCI-based switching between joint and separate TCI updates is adopted, it doesn't mean UE always has to support both modes and NW always has to configure two modes at the same time. Therefore, for Alt1, we suggest the following update:   * Alt1. A UE can be switched between joint DL/UL TCI and separate DL//UL TCI in dynamic (within the beam indication). Details are FFS.   {Mod: This is better, done}  Support proposal 1.3.  Support proposal 1.4.  Support proposal 1.5. |
| Huawei/HiSi | Proposal 1.1: The description of ‘a common (therefore, joint) TCI is shared by the above DL TCI and UL TCI’ is confusing and needs to be rephrased, such as ‘a common source reference RS is used for determining both DL QCL information and UL Tx spatial filter’.  Proposal 1.2: Alt 1 may unintentionally mandate UE to support both joint DL/UL TCI and separate DL/UL TCI if it supports R17 unified TCI. In our view, these two options are for different use cases and may have different UE capabilities. We suggest rephrasing Alt 1 as ‘if UE supports both joint DL/UL TCI and separate DL/UL TCI’.  Proposal 1.3: We think Ericsson’s suggestion (stating that the allowed source/target QCL relations in 38.214-g40 is supported for QCL-TypeD in R17) is a good way to go.  {Mod: Yes on all the above, done}  Proposal 1.5: Is it correct understanding that the proposal is to define UL TCI as QCL-TypeD, or is it just to derive UL Tx spatial filter from DL QCL-TypeD RS in the case of joint DL/UL TCI? If it is the former, as QCL-TypeD has given specific meaning and is widely used in both RAN1 (‘Spatial Rx parameter’) and RAN4, we are not sure if this is the right way to go. It is perhaps cleaner to define UL TCI as a new QCL type (e.g., QCL-TypeE, as ‘Spatial Tx parameter’ from UE perspective).  {Mod: The intention is the latter since defining a new QCL for UL doesn’t seem necessary, at least for now.} |
| Moderator2 | Re proposal 1.1, I added analogous wording for M>1 and/or N>1. Note that the wording is general enough as of now and can be expanded into several possibilities if needed.  Re proposal 1.2, for now I just want to list all the alternatives for further down selection. We can discuss in later rounds if down selection is possible in this meeting. “...by RAN1#104bis-e ...” means it can still be done in this meeting  |
| InterDigital | We provided our view in the table above. In addition, we are fine with the proposals from Moderator. |
| Qualcomm | For Proposal 1.1.   * For M=N=1, suggest the following change. Because the joint TCI is not shared by DL and UL TCI. They should have no relation to our understanding.   + Joint DL/UL TCI: A TCI implies a common source reference RS is used for determining both DL QCL information and UL TX spatial filter. * For M>1 and N>1, similar change as below. There is no relation between joint and separate TCI to our understanding.   + Joint DL/UL TCI: Each TCI implies a common source reference RS is used for determining both DL QCL information and UL TX spatial filter. In this case, M=N.   {Mod: Agree, this wording looks better (I used this wording except ‘imply’ is replaced by ‘refer’)}  For Proposal 1.2   * Is Alt.1 DCI based switching between joint and separate TCIs? If so, suggest to mention it explicitly to better differentiate from Alt.2 and 3.   {Mod: Yes}  For Proposal 1.4   * Suggest to add SSB and CSI-RS for beam management in the FFS, since both are allowed to indicate spatial relation in R15   {Mod: This has been agreed in the last meeting (which is why I used ‘also’). But I’ll add a note} |
| APT | We update our view in the table above. We are supportive of FL’s proposals. |
| Samsung3 | **For Proposal 1.1**, we suggest the following update to account for the fact that a TCI state can have two source RS for DL (e.g. QCL-TypeA and QCL-TypeD)   * Joint DL/UL TCI: A TCI refers to at least a common source reference RS is used for determining both the DL QCL information and the UL TX spatial filter.   {Mod: Yes, done}  Similar update for M>1 and/or N>1 case.  For **proposal 1.2**, we suggest to update Alt1 to be more clear:   * Alt1. A UE can be dynamically (i.e. within the beam indication signaling) switched between joint DL/UL TCI and separate DL//UL TCI ~~in dynamic (within the beam indication)~~, if the UE is capable of both joint DL/UL TCI and separate DL/UL TCI.   + Details are FFS.   {Mod: This is better wording, done}  **Proposal 1.5** We suggest moving joint TCI state to the top level.  **Proposal 1.5**: On the QCL types of a Joint DL/UL TCI State for Rel.17 unified TCI framework:   * DL large scale properties are inferred from one (qcl-Type1) or two RSs (qcl-Type1 and qcl-Type2) analogous to Rel.15/16 * UL spatial filter is derived from one RS of DL QCL Type D ~~for joint DL/UL TCI~~   {Mod: the first bullet applies to DL in general, not only to joint TCI. For the 2nd bullet, QCL type D applies to UL spatial filter only for joint TCI by reference. So the current formulation is fine. } |
| OPPO2 | **For Proposal 1.1:** we can not agree with the part with M > 1 and N >1.  If people want to support QCL per subset of PDCCH and PDSCH in single-TRP system, then rel15/rel16 can already support that. In Rel15/16, the TCI state is configured per CORESET and the PDSCH scheduled by DCI without TCI field follows the QCL of the PDCCH. By implementing that, the case of M > 1 and N > 1 can be supported. Supporting M > 1 and N > 1 in single-TRP case is against the purpose of common TCI operation.  Regarding the common TCI operation in multi-TRP case, we prefer to discuss that after we have finished the design of baseline with M = 1 and N =1. |
| ZTE2 | **Proposal 1.1**: For M=N=1, we can support it. For M>1 and/or N>1, we can NOT support it and prefer to postpone this discussion when the solution for M=N=1 is stable. We share the same views with OPPO.  Based on above summary, 14 companies support to Max=1 for sTRP only in this meeting. In technical, the association between each of M/N DL/UL TCIs and each of M/N DL/UL channel/RS subsets are unclear. Therefore, we need to have further discussion for the case/solution of M>1 and N>1 firstly, instead of supporting its general definition in rush.  **Proposal 1.2**: We can support that UE capability, but a new enabling signaling from gNB is also needed (to clarify that the gNB can support separate TCI indication or a mode of dynamically switching) considering backward compatibility. It means that a combination between candidates is also possible (e.g., Alt1+Alt2). So, the main bullet should be more general:  On Rel.17 unified TCI framework, down select or modified by RAN1#104bis-e from the following alternatives:  Regarding proposals 1.3, 1.4 and 1.5, we support all of them. |
| Huawei/HiSi2 | Proposal 1.1: For the case with M>1 and/or N>1, saying ‘M PDSCH’ may be confusing (it is not M scheduled PDSCH transmissions). We think ‘M PDSCH’ here actually means M beam pair links, and suggest rephrasing it this way.  Proposal 1.2: As Alt-2/3 are for RRC/MAC-CE respectively, we suggest rephrasing Alt-1 as DCI directly.  {Mo: Both I agree, done} |
| MediaTek | Support all of the FL proposals.  Regarding proposal 1.1, to address the concern, we suggest to add one note to clarify that this proposal doesn't mean to agree on support of either M=N=1 or M,N >=1, and the selection between them is still a working assumption. And one following typo:  >> On Rel.17 unified TCI framework, based on the agreements in RAN1#102-e and 103-e |
| AT&T | Support the current FL proposals. |
| Moderator | @OPPO, ZTE, MediaTek: As MediaTek said, the purpose is only for discussion and reaching agreements. It is now clarified in the main sentence. The working assumption to decide between =1 and >=1 in RAN1#102-e still holds. But without clear definition (and, later, understanding of use cases), any meaningful discussion is impossible. So we need a good formulation of proposal 1.1.to be agreed. |
| NTT Docomo2 | Support the FL proposals. |
| LG | Inputs are updated in Table2.  On Proposal 1.1,  - The value of M is defined for DL and N is for UL. M>1 is mainly for MTRP while N>1 is for MP-UE meaning that N>1 is possible with M=1 and vice versa. Therefore, it will be more logical if we split the cases M=1 or M>1 for DL TCI, N=1 or N>1 for UL TCI, and M=N=1 for joint TCI, etc.  {Mod: Thanks for the catch, addressed}  - In case of M>1 or N>1, it may be better to change ‘all or subset of’ into ‘subset of’  {Mod: Correct, likewise M=1/N=1, ‘all’ should suffice}  - A small typo is found on Proposal 1.2 Alt1 (i.e. separate DL//UL TCI  separate DL/UL TCI).  {Mod: Yes, done}  On Proposal 1.4, it may be better to explicitly capture the RS types supported in Rel-15/16 to remove ambiguity of ‘also supported’, e.g. using similar expression as the revised Proposal 1.3. Other proposals are ok.  {Mod: Added the missing SRS for BM} |
| Xiaomi2 | For Proposal 1.1, if it is just used for clear definition, we can support it. If it is used to decide between =1 and > 1, it is better to separate the discussion for single TRP and Multi-TRP case.  {Mod: It’s only for discussion and reaching agreements, as stated in the main sentence}  For Proposal 1.2, support both Alt 1 and Alt 3.  For Proposal 1.3, 1.4 and 1.5, support. |
| CMCC | Update our view on issue 1.6. Support the FL proposals. |
| NEC | Support the proposals. |
| vivo | For the following part, hope to add “or” in the wording. Since it is possible that reliability may only be needed for control channels, but not for data channels. For such kind of operation, it is not necessary for PDCCH/subset of PDCCH follow the same TCI.  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 one of the M DL TCIs provides common 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 one of the N UL TCIs provide a reference for determining common UL TX spatial filter at least for one of the N dynamic-grant(s)/configured-grant(s) based PUSCH, and/or subset of dedicated PUCCH resources in a CC |

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

Table 4 Summary: issue 2

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 2.1 | Assumptions on scenarios with potential higher-layer (RAN2, RAN3) impacts | RRC reconfiguration needed:   * **Yes**: OPPO * **No**: Ericsson, Apple, Qualcomm, Intel (up to RAN2), MTK, Sony, NTT Docomo, Nokia/NSB (ask RAN2 once scope has been decided (e.g. beam indication)), Futurewei, Huawei/HiSi, IDC, APT, LG   Change in serving cell:   * **Yes**: OPPO, ASUS, Qualcomm, Lenovo/MoM, ZTE * **No**: Futurewei, Intel, MTK, NTT Docomo, Ericsson (RAN2 may override), Nokia (PDSCH indication), Huawei/HiSi, APT   Change in C-RNTI:   * **Yes**: OPPO (C-RNTI is mandatory field in handover command in current RRC design), Lenovo/MoM, ASUS * **No**: Huawei/HiSi, CATT, NTT Docomo, Ericsson (RAN2 may override), Futurewei   Inter-DU (requiring RAN3) vs. intra-DU:   * **Inter-DU**: * **Intra-DU**: OPPO, Huawei/HiSi, Samsung, Qualcomm, Intel, MTK, NTT Docomo, ZTE, Ericsson, Nokia/NSB, Futurewei, IDC, APT, LG |  |
| 2.2 | Type of beam metric for measurement and reporting:  L1-RSRP or L3-RSRP | Alternatives**:**   * **L1-RSRP:** vivo, MTK, Samsung, Qualcomm (L3 can reuse existing), Intel (intra-DU can re-use L1-RSRP), Xiaomi, Sony, NTT Docomo, ZTE, Ericsson, Nokia/NSB, Futurewei, Huawei/HiSi, IDC, APT, ASUS, CMCC * **L3-RSRP:** OPPO, Lenovo/MoM, Xiaomi (L3-RSRP only for triggering beam measurement of non-serving cell) * **Hybrid L1+L3-RSRP:** Apple, CATT (with SD filter L3-RSRP) |  |
| 2.3 | Beam measurement/reporting mechanism | Content of reporting:   * Only one (Beam metric,SourceRS) pair: * More than one (Beam metric,SourceRS) pairs: Ericsson, Samsung, vivo, Qualcomm, Futurewei, Lenovo/MoM, Sony, Spreadtrum, CATT, NTT Docomo, ZTE, Huawei/HiSi, IDC, APT,CMCC   Event-based beam reporting for non-serving cell(s) – event FFS:   * **Yes**: Xiaomi, Apple, Huawei/HiSi, Sony, Samsung, ZTE, Nokia/NSB, Lenovo/MoM, IDC, ASUS, CMCC * **No** (pre-configured): Qualcomm, NTT Docomo, Ericsson (can be discussed later), Futurewei, APT   NW-initialized beam reporting for non-serving cell(s)   * **Yes**: ZTE, Ericsson, Futurewei, ASUS * **No**: |  |
| 2.4 | QCL enhancement (including TCI state definition) | Where to include PCI of non-serving cells:   * In CSI-SSB-ResourceSet: Nokia/NSB, MTK, vivo * Per TCI state: vivo, LGE, Intel, Sony, Qualcomm, NTT Docomo (a new ID for PCI indication), ZTE (also add MeasObject ID), Nokia/NSB, Futurewei, Lenovo/MoM, IDC * Signaled via MAC CE: CATT * Implicit (re-indexing with SSB/source RS index): Xiaomi, Samsung, * A new RRC IE to include the information (including PCI) of non-serving cell: OPPO, Huawei/HiSi, ASUS, CMCC   Where to include SSBs/source RSs of non-serving cells   * Per TCI state: Nokia/NSB, Ericsson, Samsung, Qualcomm, MTK, Lenovo/MoM, Xiaomi, Sony, Spreadtrum, CATT, NTT Docomo, Nokia/NSB, Futurewei, LG (MO + PCI/SSB), CMCC * Per TCI state group: Apple (per SSB configuration) |  |
| 2.5 | Additional source RS type(s) | CSI-RS for mobility:   * **Yes**: Lenovo/MoM, Huawei/HiSi, LGE, Sony. CATT, ZTE * **No**: Samsung, Qualcomm, Intel, MTK, Apple, OPPO, Nokia/NSB, Futurewei   CSI-RS for tracking:   * **Yes**: Samsung, ZTE, Futurewei, Huawei/HiSi * **No**: Qualcomm, Intel, MTK, OPPO, Nokia/NSB   CSI-RS for BM:   * Yes: Futurewei * No: | Note: SSB has been agreed  Note: This also depends on the type of beam metric |
| 2.6 | TCI state for CORESET #0: if we can indicate a TCI state associated with non-serving cell SSB to CORESET#0 | **Yes**: OPPO, Huawei/HiSi  **No**: |  |

**Proposal 2.1**: On Rel.17 enhancements for L1/L2-centric inter-cell mobility, intra-DU only is assumed.

**Proposal 2.2**: On Rel.17 multi beam measurement/reporting enhancements:

* Quality of up to K beams associated 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)
  + FFS: Activation/deactivation for the CSI-reportConfig
* FFS: Whether beam reporting associated with non-serving cell(s) can be mixed with that with serving-cell in one reporting instance

Table 5 Additional inputs: issue 2

|  |  |
| --- | --- |
| **Company** | **Input** |
| Intel | From our perspective, all proposals in 2.1 should be up to RAN2. RAN1 can only specify QCL enhancement in 2.4. |
| MediaTek | On item 2.5, does it want to discuss whether CSI-RS configured for non-serving cell can be used as source RS in the TCI state? If yes, we believe it is not needed since CSI-RS configured for serving cell associated with non-serving-cell SSB can achieve the same purpose. |
| Apple | We provided our views for some issues in Table 4 |
| vivo | Some views included. |
| Xiaomi | We provided some views in Table 4 |
| Sony | We provided our additional views in the table above. |
| Spreadtrum | Inputs updated for #2.3 |
| NTT Docomo | Item 2.1: Change in serving cell: We think it would be complicated to change the serving cell and CORESET#0 (this is a reason why we think “No”).  Issue 2.4: Per TCI state: There is no need to configure PCI directly in QCL/TCI; instead, new ID can be configure to identify the serving cell (e.g. if only one non-serving cell is configured, 1-bit is sufficient for the new ID. If two or three non-serving cells are configured, 2-bit is sufficient for the new ID).  To configure PCI directly in QCL/TCI state has RRC overhead issue: One PCI has 10bit in RRC signaling. If we have 64 TCI states configurations from non-serving cell, then it costs 640bits. In addition, if we want to configure non-serving SSB in L1 beam measurement/reporting, each CMR of non-serving SSB will cause 10 bits. The total overhead is not so small. On the other hand, with a new ID, if there is only one non-serving cell, new ID of 1-bit is sufficient to indicate the non-serving cell. Large signaling overhead can be saved. |
| ZTE | Proposal 2.1: Support in principle. In our views, the definition of ‘no RRC reconfiguration’ is unclear for us. For instance, we configure/reconfigure multiple candidate parameters in RRC, and then we down-select/activate some of them by L1/L2 signaling. So, we need to call it as RRC reconfiguration or not. From our perspective, ‘intra-DU’ is sufficient and clear.  Proposal 2.2: the motivation of last bullet of “At least one out of the K pairs can correspond to a configured non-serving cell” is unclear and should be up to implementation rather than being criterion. From our perspective, we only need to discuss how to configured RS to be measured/reported from a neighboring cell.  Besides, on issue 2.3, can we add one more bullet related to NW-initialized beam reporting for non-serving cell(s) as another candidate solution? From ZTE perspective, we can support it also.  On issue 2.4, we share the same views with NTT DOCOMO that new ID of 1-bit that is indicated candidate PCI pre-configured is sufficient. |
| Ericsson | Proposal 2.1: support – as a RAN1 assumption. RAN2 may override, of course.  Proposal 2.2: support  Regarding 2.4, it may be beneficial to split this into purposes: i) how do we enhance QCL for measurements ii) how do we enhance QCL for beam indication |
| OPPO | Proposal 2.1: we do not support that because we cannot simply assume there is no RRC reconfiguration for inter-cell mobility. According to the current inter-cell mobility design, RRC reconfiguration is mandatory (a minimum RRC reconfiguration is transmitted, which is not avoidable)  Regarding the RRC reconfiguration during inter-cell mobility, the following minimum RRC reconfiguration is needed:   * The PCI of the target cell. Otherwise, the UE does not where to handover to during the inter-cell mobility. * The RRM measurement reconfiguration. * Some system information of the new cell * The configuration of the SS#0 of the new cell, which is derived from the system information of new cell. * In current RRC design, the C-RNTI is mandatory field in handover command.   Proposal 2.2: we only support based on L3 measurement. The current text in proposal 2.2 looks like we are going to support L1 measurement.  {Mod: L1 measurement is one candidate, cf. issue 2.2. Added FFS to clarify} |
| Nokia/NSB | Proposal 2.1: it is not possible to say that RRC configuration is/is not needed by RAN1. RAN1 may try to prefer a solution where there is limited RRC impact. RAN1 should decide first whether beam indication is supported, and then decide whether to support PDCCH or PDSCH or both. Hence proposal 2.1 is not needed.  Proposal 2.2: in case multiple cells are reported in a single reporting instance the reporting formats may need to be updated. in case only on cell is reported in a reporting instance, potentially no update is needed  In order to proceed, we should refrain from using the term “inter-cell mobility” in proposal 2.2  {Mod: Yes} |
| Futurewei | Our views are updated in the table above.  Proposal 2.1: Support.  Proposal 2.2: Support. |
| Intel | **Proposal 2.1:** It may be up to RAN2 to conclude on this based on RAN1 design. This can be RAN1 assumption but may not be needed.  **Proposal 2.2:** The last bullet “At least one out of the K pairs can correspond to a configured non-serving cell” is not needed. It is up to implementation whether non-serving cell report is included or not. Based on the same argument, the first bullet should be as follows:   * K1 (Beam metric, Source RS indicator) pairs can be reported   On the issue of actual PCID inclusion in TCI state, it may be up to RAN2 to design explicit or implicit indication. |
| Samsung2 | We are OK with proposal 2.1  For proposal 2.2, we assume that a beam measurement report is used for serving and non-serving cells. In this, the source RS indicator can be from a non-serving cell. There is no need to have at least one pair from a non-serving cell, for example the UE might not find any strong beams from the non-serving cell. We suggest to update as follows:  **Proposal 2.2**: On beam measurement/reporting enhancements to enable Rel.17 L1/L2-centric inter-cell mobility:   * K>1 (Beam metric, Source RS indicator) pairs can be reported   + Source RS indicator can correspond to an RS associated with a non-serving cell.   + FFS: Maximum value of K   + FFS: If K is fixed, configured, or dynamically selected * ~~At least one out of the K pairs can correspond to a configured non-serving cell~~   {Mod: The original wording “At least one ... *can* ...” denotes contingency. So it doesn’t have the alleged issue. The rewording is not preferred since it only states “source RS indicator which causes ambiguity in relation to the respective beam metric.} |
| MediaTek2 | Support FL proposal 2.1. This proposal only captures the assumptions when RAN1 does any enhancement for L1/L2-centric inter-cell mobility in Rel-17. Suggest the following to avoid misunderstanding:  **Proposal 2.1**: In Rel.17 enhancement for L1/L2-centric inter-cell mobility, the followings are assumed :   * No RRC reconfiguration * Intra-DU only   {Mod: Yes, done}  On FL proposal 2.2, support in principle. According to current RAN4 requirements (TS 38.133), there should be at least one L1-RSRP measurement reporting for a target TCI state within a period before UE performs DL reception with a TCI state, where the RS for L1-RSRP measurement is the RS in the target TCI state or QCLed to the target TCI state. In order to allow a TCI state associated with non-serving-cell RS(s) to be used for DL reception and UL transmission, the same rule should be reused, which means at least L1-RSRP measurement reporting has to be introduced for non-serving-cell RS. However, maybe we can reach an agreement on support of L1 measurement/report on RS associated with a non-serving cell before discussing the details how to report.  {Mod: Good point we need to discuss in later round(s)} |
| Huawei/HiSi | Proposal 2.1: As the WID already said ‘as opposed to RRC’, agreeing on these detailed assumptions would help making progress. And we suggest taking that C-RNTI is assumed to be unchanged as a WA (RAN2 can override).  {Mod: We will discuss this in later round(s). For round 0 we can finalize the DU case first.}  Proposal 2.2: Why ‘source RS’ is mentioned in reporting, and shouldn’t it be ‘measured’? The last bullet of ‘At least one out of the K pairs…’ may imply the possibility of mixing serving/non-serving cell measurement/report(s), which has not been discussed, and we suggest removing this sub-bullet.  {Mod: Yes, done} |
| InterDigital | We are fine with the proposal 2.1. What’s the meaning of pairs in the proposal 2.2? We don’t think that the proposal is clear and more generic principle should be agreed before proposing a design based on ‘pairs’.  {Mod: The term ‘pair’ (originally intended for (Index,Metric)} is removed) |
| Qualcomm | Support both Proposal 2.1 and 2.2 |
| APT | We are supportive on both proposals. |
| Samsung3 | In **proposal 2.2**, to be more clear we suggest updating as follows:  **Proposal 2.2**: On Rel.17 multi beam measurement/reporting enhancements:   * Up to K metric pairs ~~>1 (Beam metric, Measured RS indicator) beam reports~~ associated with non-serving cell(s) can be reported in a single reporting instance, where K>1   + Each metric pair includes (Beam metric, Measured RS indicator).   + FFS: Maximum value of K   + FFS: If K is fixed, configured, or dynamically selected   + FFS: The type of beam metric (e.g. L1-RSRP, L3-RSRP, or hybrid L1/L3-RSRP) * FFS: Whether beam reporting associated with non-serving cell(s) can be mixed with that with serving-cell in one reporting instance   {Mod: Agree this is much clearer, also addressed potential ambiguity, cf. IDC. I use report-pair instead of metric pair.} |
| ZTE2 | Proposal 2.1: Support.  Proposal 2.2: We can support the further updated with minor modification: K>= 1  {Mod: done, “K>1” is removed and FFS: maximum K is already there} |
| MediaTek | We support proposal 2.1  We support proposal 2.2 but one question for clarification. According to current wording, it seems this proposal is going to introduce a layer-1 reporting (i.e., UCI reporting) to support this functionality, instead of MAC-CE or something else. Is my understanding correct?  {Mod: That’s correct – it will be an L1 reporting in the form of CSI/UCI. I added “CSI” to be clear} |
| ASUSTeK | We support both proposals, and our views are further updated on the table above. |
| NTT Docomo2 | Support FL proposal 2.1 and 2.2. |
| LG | Inputs are updated in Table 4 and we support the FL’s proposal 2.1 and 2.2. |
| Apple | We suggest some revisions for proposal 2.2 as follows. Similar terminology like “report-pair” is used for discussion in mTRP BM enhancement but with a different meaning.  **Proposal 2.2**: On Rel.17 multi beam measurement/reporting enhancements:   * Quality of up to K beams associated with non-serving cell(s) can be reported in a single CSI reporting instance   + For each beam, UE can report: (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)   + FFS: activation/deactivation for the CSI-reportConfig * FFS: Whether beam reporting associated with non-serving cell(s) can be mixed with that with serving-cell in one reporting instance   {Mod: I agree this rewording is better, done} |
| Xiaomi | Support Proposal 2.1.  As for Proposal 2.2, we think it is better to change “report-pair” to “report-set” for differentiating pairs in group based beam reporting. In addition, we want to clarify that it can also be applied for more than one non-serving cell, right? If yes, we think it need to restrict that it is for non-serving cell(s) with same component carrier and the PCI may also be included in the report-set. And it is better to change the description as follows:   * + Each report-set includes at least: (1) a Measured RS Indicator, and (2) a Beam Metric associated with the Measured RS Indicator   {Mod: Yes, the above can be discussed later – for now we focus on reporting format. ‘at least’ is added. Regarding terms, Apple’s suggestion should resolve the confusion.} |
| CMCC | We update our views in Table4. On issue1, whether RRC reconfiguration is needed should be up to RAN2.  {Mod: This is a very good point, we will discuss in later round(s) – indeed some of the assumptions can be left to RAN2 and RAN1 may focus on measurement/reporting and QCL issues} |
| NEC | Support the proposals. |

### Issue 3 (beam indication signaling medium)

Table 6 Summary: issue 3

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 3.1 | Beam application time definition:  Alt1: Measured from DCI reception  Alt2: Measured from ACK transmission | **Alt1 (DCI):** Spreadtrum, Xiaomi, Ericsson, CATT, MTK, NEC, Samsung  **Alt2 (ACK):** IDC, Lenovo/MoM, Fujitsu, Nokia/NSB, CMCC, Apple, Huawei/HiSi, ZTE, vivo, Intel, Sony, Qualcomm, NTT Docomo, APT  **Alt1 and Alt 2:** OPPO (Since Alt1 considers the requirement of UE and Alt2 considers the requirement of gNB side), LG | Other aspects mentioned for next-level details: when TCI state is unknown, panel activation/deactivation, PUCCH repetition |
| 3.2 | Configurability of beam application time  Alt1: UE capability  Alt2: Fixed in spec | **Alt1 (UE capability):** IDC, Fujitsu, Nokia/NSB, Xiaomi, Ericsson, Apple, ZTE, CATT, vivo, MTK, Intel, Qualcomm, NTT Docomo, Samsung, Sony, Spreadtrum, Lenovo/MoM, LG  **Alt2 (fixed):** Lenovo/MoM, Huawei/HiSi  **Alt1+Alt2:** OPPO (The application time is determined based on both Alt1 and Alt 2 in 3.1. Therefore for Alt1 of 3.1: fixe in Spec and Alt2 of 3.1: UE capability) |
| 3.3 | Additional design details on agreed DCI formats 1\_1/1\_2 for Rel.17 unified TCI framework beam indication (TCI state update) | How to support separate DL/UL TCI:   * **New field to indicate UL TCI:** Xiaomi, ZTE, Intel, Samsung, Qualcomm, Nokia/NSB * **MAC CE to pair DL TCI and UL TCI:** OPPO, Xiaomi, Ericsson, Huawei/HiSi, MTK, Apple, vivo, Spreadtrum, CATT, Convida, Nokia/NSB * **Different RNTIs for DL vs UL TCI:** Futurewei, Intel * **Add a DCI field to indicate DL vs UL TCI:** Intel * **Implicit (depending on to which channels the TCI applies):** Lenovo/MoM, LG   Support for an additional dedicated ACK mechanism for the DCI based on SPS PDSCH release:   * **Yes**: ZTE, NEC, Samsung, Qualcomm, Intel (for grant-free DCI), Sony, NTT Docomo (if no PDSCH is scheduled) OPPO (DCI 1\_1/1\_2 without DL assignment) , Nokia/NSB * **No**: Ericsson, MTK, vivo, Futurewei (DCI with DL assignment already has ACK for PDSCH), Huawei/HiSi, APT, LG | Note: The agreement encompasses only DCI formats 1\_1/1\_2 with DL assignment |
| 3.4 | Support for additional DCI formats for Rel.17 unified TCI framework beam indication (TCI state update) | DCI formats 1\_1/1\_2 without DL assignment:   * **Yes**: OPPO, Fujitsu, Spreadtrum, Nokia/NSB, CATT, vivo (at least for UL-only TCI), MTK, Qualcomm, Samsung, Apple (ACK/NACK mechanism is needed), vivo, Lenovo/MoM, Convida, NTT Docomo, ZTE (ACK/NACK is needed), NEC (ACK/NACK needed) * **No**: Ericsson, Huawei/HiSi, LG   DCI formats 0\_1/0\_2 with UL grant:   * **Yes**: IDC, Nokia/NSB, Xiaomi (at least for UL-only TCI), ZTE (at least for UL-only TCI), MTK, LGE, Intel, Sony (Study), Qualcomm * **No**: OPPO, CMCC, Ericsson, Huawei/HiSi, Convida, Apple, vivo, Spreadtrum, CATT, NTT Docomo, NEC   Dedicated DCI format for beam indication, with dedicated ACK based on SPS PDSCH release:   * **Yes**: Futurewei, ZTE, CATT, Intel, Sony, NTT Docomo(keep the same DCI payload as existing DCI format), OPPO (based on format 1\_0 without DL assignment), Samsung, Nokia/NSB (based on format 0\_1/0\_2 without UL grant), Qualcomm , Lenovo/MoM, APT (based on SPS or CG release DCI), NEC * **No**: Ericsson, MTK, Convida, Apple, vivo, Huawei/HiSi, LG   **Support extending existing DCI formats for UL-only TCI**: APT |  |
| 3.4 | HARQ-ACK codebook issues | **Only positive ACK for alignment:** OPPO, vivo, Spreadtrum, Huawei/HiSi  **Dedicated A/N bit in codebook**: Lenovo/MoM, Apple, Qualcomm , MTK |  |
| 3.6 | Support for group-based DCI in Rel.17 unified TCI framework | * **Yes:** ZTE (study), Intel, Sony (study), Qualcomm, Samsung, MTK, Lenovo/MoM, CATT, NTT Docomo * **No:** IDC, Apple, vivo, Spreadtrum, Ericsson, Huawei/HiSi, LG |  |

**Proposal 3.1**: 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

Table 7 Additional inputs: issue 3

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| --- | --- |
| **Company** | **Input** |
| Intel | Our inputs are updated in Table 6.  In 3.3, what is difference between “**New field to indicate UL TCI**” and “**Add a DCI field to indicate DL vs UL TCI**”? In our understanding both need additional new DCI field. |
| MediaTek | Inputs updated in Table 6. |
| Apple | We provided our views for some issues in Table 6 |
| vivo | Some views included |
| Lenovo/MoM | Issue 3.2: It is possible for gNB to incorporate different UE capabilities (beam switching time) into the delay from DCI to ACK as part of implementation. That is the reason we propose a fixed time from ACK to beam application. This also makes the specification simpler. However if most companies believe Alt 1 is better, we can go with Alt 1.  Issue 3.3: If the DCI signals to which channel(s) the TCI applies to, the UE can derive whether the TCI is a DL or an UL TCI. For example, PDSCH implies DL TCI and PUSCH implies UL TCI.  Issue 3.4: If positive ACK for PDSCH is reused, the case of successful DCI/unsuccessful PDSCH decoding cannot be differentiated, the reliability of PDCCH is affected by PDSCH and leads to poor performance. |
| Sony | Our additional views are added in above table. |
| Spreadtrum | We added our preference in Table 6 |
| Convida Wireless | OK with the FL proposal. |
| NTT Docomo | Issue 3.1: Alt. 1 has an issue (as figure below). If the beam indication DCI is missed, gNB updates the assumption of the unified TCI state, but UE does not know even the beam indication DCI comes or not, and hence, UE monitors DCI on previous beam. In this case, the misalignment of the bam assumption happens. Since the error requirement of PDCCH detection is 1%, this issue happens in 1% probability, which we cannot ignore from system perspective.    Figure. Issue of Alt. 1 (beam application after beam indication DCI).  Support FL Proposal 3.1. |
| ZTE | OK with the FL proposal in principle. Could any proponents can clarify the meaning of last bullet. Why we need to consider the maximum value of beam application time?  {Mod: It was taken straight from the previous agreement  I believe from Qualcomm. Since it was a copy-and-paste, it was agreed and removing it would require some more discussion for closure. } |
| Ericsson | Support FL proposal 3.1  Questions:  - is the idea to support several beam indication mechanisms based on DCI? All of them would be different UE capabilities, so there is a large risk of market fragmentation.  - what would be the motivation for a DCI format 1\_1 and 1\_2 without DL grant?  {Mod: These are valid questions we need to discuss very carefully in later round(s).} |
| OPPO | Regarding proposal 3.1: we do not support it for the current moment.  In our view, we shall consider both Alt1 and Alt 2 to determine the application time. And we prefer to first dicuss that before we dicuss the UE capability.  {Mod: Based on OPPO2 comment, proposal 3.1 should be agreeable with the added FFS} |
| Nokia/NSB | We support FL proposal 3.1 |
| Futurewei | Our views are updated in the table above.  Support FL Proposal 3.1. |
| OPPO2 | For Issue 3.1 (how to determine the application time), we need to consider the time requirement at both UE and gNB.  Assume one DCI indicating TCI is received at slot n and the ack to the TCI indication is sent at slot n+m:     * At the UE side: the minimum time the UE need to switch to the new TCI state include: a time used to decode the DCI and a time used to prepare the new Rx beam (or even including activating the new Rx panel). So the earliest time point when the UE can switch to the new TCI state is t1 after the DCI. * At the gNB side: the gNB switch to new TCI state only after receives the ack from the UE. The time length the gNB needs include (1) the time decode the ACK and (2) the time used to switch the Tx beam. Overall, the earliest time point that the gNB can apply the new Tx beam is t1 after the ack.   Therefore, the earliest time point when both gNB and UE can switch to the new Tx beam/TCI state is the time point that can meet both conditions:   * Condition 1: at least t1 after the DCI, which is the UE capability. * Condition 2: at least t1 after the ack, which considers the gNB requirement. |
| Samsung2 | We are fine with proposal 3.1.  Regarding DOCOMO’s comment on the issue with Alt1 for potential misalignment. This can potentially be an issue if the X/Y values are not judiciously selected. We would like to point out that:   1. In Rel-15/16 when a TCI state is indicated in a DCI it applies to the PDSCH associated with that DCI if the time gap between the PDCCH and PDSCH exceeds a threshold. Not supporting this in Rel-17 could lead to some loss in performance. 2. If X/Y is large enough, it can lead to a beam switch after the PUCCH with the corresponding HARQ-ACK. This in turn avoids misalignment.   If there is a single X/Y value signaled to the UE, the network can choose either 1 or 2, both can’t be satisfied at the same time. But we can leave this to network implementation depending on the scenario. With Alt2, it is not possible to apply to the TCI state in the DCI to the corresponding PDSCH.  If two X/Y values are configured, one can apply to the PDSCH and the other can apply to other channels not associated with the DCI. The second value can be large enough to make the beam switch after the corresponding PUCCH. If the network doesn’t get an indication in the PUCCH that the DCI was received, no beam switch takes place.  A third option is to have a single X/Y and do the beam switch before the PDSCH. If the DCI is missed, the network fails to receive an indication from the UE that the TCI state was received and reverts back to the original beam. In this scenario, the misalignment is between the time of beam switch and the time network should have received the HARQ-ACK (plus any processing time). As you said PDCCH failure is 1% of the time, so this should be a relatively rare occurrences one in a hundred TCI state updates will be missed and have small beam misalignment time between UE and gNB. |
| MediaTek2 | We support FL proposal 3.1  On DOCOMO’s comment on the issue with Alt1, we share similar view with Samsung.  If single X/Y is assumed and UE doesn't receive the DCI indicating a new TCI state:   * Alt1: UE still applies original TCI state and no acknowledgement in response to the DCI. NW applies a new beam to receive the acknowledgement but nothing is received, and assumes that the original TCI state is still applied by UE. -> No ambiguity. * Alt2: UE still applies original TCI state and no acknowledgement in response to the DCI. NW applies an old beam to receive the acknowledgement but nothing is received, and assumes that the original TCI state is still applied by UE. -> No ambiguity.   There is only a small duration that misalignment may happen but it will be fixed after the time of HARQ-ACK. |
| Huawei/HiSi | Proposal 3.1: We still think agreeing on one fixed value for one use case (intra-cell beam switching, UE panel switching, triggering neighbor cell measurements) would be the cleanest design (smallest efforts on handling different timelines at both NW and UE), and prefer to have more discussions on this. |
| InterDigital | We are fine with the proposal. |
| Qualcomm | Support Proposal 3.1 |
| APT | We are fine with the proposal. We would like to clarify if a UE is allowed to report more than 1 values since it was agreed to have different panel capability.  {Mod: Done} |
| ZTE | Support Proposal 3.1 |
| NTT Docomo2 | We are fine with FL proposal 3.1.  Thank you Samsung/MediaTek for your comments on issue 3.1. Please let us response to the comments:  To Samsung2, our proposal is to update the common beam after ACK transmission (i.e. Alt. 2) but the new beam is applied to the scheduled PDSCH and HARQ transmission before updating the unified TCI state (as illustrated below). Same as Rel. 15, if the scheduling DCI is missed, UE does not receive PDSCH and transmits ACK, there is no issue to update the beam of PDSCH/ACK by the beam indication DCI.  This proposal solves the 1st problem of Alt.2 which Samsung pointed out.  For the 2nd comment (i.e. larger X/Y enables to update the unified TCI after ACK), it is equivalent to Alt.2. As you explained, Alt. 1 enables switching between “fast beam application (small X/Y)” and “reliable beam applications (larger X/Y)”. However, the updated Alt. 2 (below figure) satisfies both simultaneously.    Figure. Updated Alt. 2 (New beam is applied to the scheduled PDSCH/HARQ before updating the unified TCI state)  To MediaTek2, in your explanation, gNB should take care of two possibility of UE assumption for each UE, case-1 is old beam (when UE missed the beam indication DCI), and case-2 is new beam (when UE received the beam indication DCI). After gNB’s assumption is updated to new beam, if gNB does not receive the HARQ, gNB should re-send the beam indication DCI in old beam to update the unified TCI state. Generally, this (taking care of two possibility of UE assumption for each UE) is complicated and not preferred from operation/NW implementation perspective. |
| LG | Inputs are updated in Table 6 and we support the FL’s proposal 3.1.  On Issue 3.1, to our understanding,   * DL part: There will be a PDSCH after receiving the DCI and this DCI-to-PDSCH time gap is already determined by UE capability, beamSwitchTiming (BST). We think that existing timing is sufficient for DL part. * UL part: The issue is about UL beam application time because BST has not been impacted on UL. Compared with DL BAT, additional delay for UL BAT may need to be considered, e.g. Tx power saturation delay. In addition, for MP-UE, it needs to be consider how to accommodate Tx/Rx panel activation status into the BAT.   Hence, to exploit the benefits based on DCI, it is possible to different BAT configuration, e.g. Alt1 for PDSCH (timingDurationForQCL) and Alt2 for other channels. |
| Xiaomi | Support Proposal 3.1. |
| NEC | Support the proposal. |

### Issue 4 (MP-UE)

Table 8 Summary: issue 4

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 4.1 | Entity pertaining to an UL panel for the purpose of UE-initiated panel selection (of one) and activation (of ≥1)  Note: support for UE-initiated panel selection/activation was agreed (but spec support is still FFS – see 4.2) | Alternatives:   * Newly defined panel ID(s): Lenovo/MoM (study), LGE, Xiaomi, NTT Docomo, Qualcomm, Spreadtrum, ZTE, Huawei/HiSi (virtual concept without mandating physical UE panel implementation), IDC, APT,CMCC   + Not needed: AT&T, CATT, Ericsson, OPPO, Nokia/NSB * SSBRI(s)/CRI(s) or CSI-RS resource set ID(s): IDC, Samsung, MTK(SSBRI(s)/CRI(s)), Xiaomi, CATT * SRI(s) or SRS resource set ID(s): vivo, Qualcomm, Xiaomi, Sony (SRS resource set ID(s)), Fraunhofer IIS/HHI, Huawei/HiSi, APT * Antenna port group: Apple, Qualcomm, Nokia/NSB |  |
| 4.2 | Spec support for UE-initiated panel selection and activation | Potentially new beam reporting format, including enhanced beam-group reporting (indicator(s) depending on the outcome of issue 4.1 + beam metric(s)):   * **Yes**: ZTE, APT, NTT Docomo, Samsung, MTK, vivo, Qualcomm, Xiaomi, Spreadtrum, Nokia/NSB, Huawei/HiSi, LG,CMCC * **No**: CATT, OPPO   UE-initiated reporting mechanism (beyond NW-configured P/SP/AP reporting, including switching event):   * **Yes**: Huawei/HiSi, Samsung, CATT, IDC, MTK, NTT Docomo, Fraunhofer IIS/HHI, Sony, Xiaomi, Apple, Lenovo/MoM, Qualcomm, Nokia/NSB, APT, AT&T, LG * **No**: MTK, Spreadtrum, ZTE (motivation is unclear), Ericsson, OPPO   gNB confirmation (hand-shake) of UE panel choice:   * **Yes**: IDC, Huawei/HiSi, Qualcomm (UE decides which panel to activate), NTT Docomo, LG * **No**: MTK (confirmation according to TCI stat activation), Spreadtrum, CATT, ZTE (same views with MTK), Ericsson (same view as MTK), OPPO, Nokia/NSB |  |
| 4.3 | Support for NW-initiated UL panel selection and activation | NW-initiated UL panel selection (of one) and activation (of ≥1)   * **Yes**: IDC, Huawei/HiSi, ZTE, LGE, NTT Docomo,CMCC * **No**: OPPO, Fraunhofer IIS/HHI, CATT, MTK, Intel, Sony, Xiaomi, Qualcomm (NW can initiate selection within active panels but not activation), Spreadtrum, Nokia/NSB   NW-to-MPUE signaling of panel selection/activation:   * **Yes**: NTT Docomo, Lenovo/MoM, Xiaomi, APT, IDC (panel ID in TCI state), Samsung (in case of MPE), CATT, APT, vivo, Qualcomm (NW can signal which active panel to use but not activation), Spreadtrum (select among active panels), Nokia/NSB, Huawei/HiSi (with UE confirmation/rejection), LG,CMCC * **No**: OPPO |  |
| 4.4 | Support for per-panel UL PC and TA | Per-panel UL PC:   * **Yes**: Huawei/HiSi, LGE, Lenovo/MoM, Qualcomm, ZTE * **No**: Apple, Ericsson, OPPO, Nokia/NSB   Per-panel UL TA:   * **Yes**: Huawei/HiSi, LGE, Qualcomm, ZTE * **No**: Apple, Spreadtrum, OPPO |  |
|  |  |  |  |

**Proposal 4.1**: On Rel.17 enhancements to facilitate UL beam selection for MP-UE, the following terms are used at least for discussion and agreement purposes:

* ‘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

Table 9 Additional inputs: issue 4

|  |  |
| --- | --- |
| **Company** | **Input** |
| MediaTek | Inputs updated in Table 8.  On Item 4.2, in the last meeting, there are several use cases are agreed for facilitate fast UL panel selection for MP-UEs. Then, it would be difficult to define the event(s) to trigger the report. Thus, we prefer not to use UE-initiated reporting mechanism and keep the purpose of UL panel selection/activation transparent to NW. |
| Apple | For 4.2, we are not quite sure about the meaning of “gNB confirmation”, there may be two different interpretation:   * Interpretation 1: the gNB confirmation is an UL TCI switching * Interpretation 2: the gNB confirmation is to confirm UE can use one panel for a UL TCI   In our view, we think UE can select the panel for a potential gNB beam, and this gNB confirmation is like a beam switching, when gNB asks to switch to the new beam, UE would change panel accordingly.  We also have similar question to 4.3, is this panel selection like a TCI switching or not? |
| vivo | Some views included. |
| Xiaomi | We provided some views in Table 8. |
| Sony | Additional views are added. |
| Spreadtrum | For #4.2, panel activation/deactivation event should not happen frequently, therefore panel status information carried by NW-configured P/SP/AP reporting should be enough. Besides, we don’t think gNB confirmation procedure is important. Instead, we can discuss default beam for UL channels/RSs when they are triggered to be transmitted with a deactivated panel. |
| CATT | For now our preference is to rephrase proposal 4.1 as a candidate scheme for study this week. |
| NTT Docomo | We suggest separating the discussion of “NW initiated **panel selection**” and “NW initiated **panel activation**”.  In our understanding,   * NW initiated **panel activation** intends to support NW decides and indicates which panels to be activated/deactivated * NW initiated **panel selection** intends to support NW decides and indicates one panel used for UL Tx from multiple activated panels. And which panel to be activated/deactivated can be up to UE’s decision or NW’s decision. |
| Fraunhofer IIS/HHI | Some views updated |
| ZTE | We support FL proposal.  Regarding item 4.2, the motivation of “UE-initiated reporting mechanism (beyond NW-configured P/SP/AP reporting, including switching event)” is unclear to us. As MTK mentioned, we do not need to specify this event clearly, and alternatively the reporting procedure is just initialized by gNB. Periodically, the UE can report the active/inactive state of UE UL panel(s) in each of corresponding report instance(s). |
| Ericsson | Don’t support. There is no need for a report to facilitate UE-initiated panel selection – the UE can freely deactivate panels corresponding to deactivated TCI states, but not activated TCI states  The other operation we need to discuss is scheduling – how does the NW schedule the UE? For 4.1, it is not clear to us why we would need an entity pertaining to a UE panel for the purpose of UE-initiated panel activation. For the purpose of UE-initiated panel activation, the only relevant purpose would seem to be UE-to-NW reporting and as a scheduling indicator. Suggest clarifying scope before we discuss definition.  For 4.2, there is already a UE-initiated reporting defined in RAN4  For 4.3, what would “panel selection” be? The NW can schedule UL transmissions, is that panel selection?  For 4.4, it is unclear what “per panel PC” means: is different parameters? Clearly, the UE could use different transmit powers on different panels. Regarding TA, the UE should automatically adjust its transmit timing. |
| OPPO | Do not support Proposal 4.1.  The motivation is not clear and seems not aligned with WID. As sated in WID, the objective for UL panel selection is for„UL coverage loss mitigation due to MPE“. So we shall only considering the MPE issue as the motivation here. |
| Nokia/NSB | We suggest to have further discussion before to agree on something at this moment.  We also think SSBRI/CRI based UL beam management can actually support UL panel selection without introducing new index such as panel ID. We don’t think any explicit panel awareness is needed.  For #4.4, we may need to clarify what ‘panel specific’ power control exactly means, since we already support beam specific power control where different power control parameters can be applied within the same panel |
| MediaTek2 | Support FL proposal in principle.  In the last meeting, it was agreed that UL panel(s) may be a subset of DL panel(s), which means when UE activate multiple panels, a panel may be activated for both DL reception and UL transmission, or DL reception only. For example, in order to avoid transmit power back-off due to MPE, UE may activate a panel for UL transmission alternative to a panel for DL reception only. If multiple panels are activated and only a subset of the panels are activated for UL transmission, in order to let NW know how to schedule UL transmission on the UL panel(s) instead of the DL-only panel(s), UE should indicate beam pair link(s) that are feasible for UL transmission on the UL panel(s) to NW. In summary, we see specification support for UE-initiated UL panel selection/activation is necessary if UL panel(s) can be a subset of DL panel(s). However, indeed, whether panel ID or other indicator is needed can be further discussed. Thus, we suggest the following:    **Proposal 4.1**: To facilitate UE-initiated panel selection (of 1 out of L activated panel(s)) and activation (of L panels) for Rel.17 MP-UEs, support at least the following:   * Enhanced beam reporting format, including enhanced beam-group reporting to indicate feasible NW beam(s) and/or UE panel(s) for UL transmission   FFS: indicator(s) associated with the reported beam(s) |
| Huawei/HiSi | Suggest updating ‘beam-group reporting’ as ‘group-based beam reporting’. |
| Moderator | Based on the inputs received above and offline (my initial proposal 4.1 is not acceptable to 5 companies), it seems necessary at least to define (1) panel activation and selection – see revised proposal 4.1, (2) what a panel constitutes (will be discussed in the next round(s) – Apple’s proposal (group of ports) is a good starting point). |
| InterDigital | We are fine with the proposal. |
| Qualcomm | Support Proposal 4.1 |
| APT | We are not clear of the definition of “panel selection” in the proposal. If panel activation/deactivation is UE’s decision. “panel selection” part should be left to NW decision.  {Mod: Good point, since we haven’t agreed to any of this, I moved “UE” to the back } |
| ZTE | We share the same views with APT that “panel selection” part should be left to NW decision. Considering UE initialized panel activation, we have the following modification:  **Proposal 4.1**: On Rel.17 enhancements to facilitate UL beam selection for MP-UE, the following terms are used at least for discussion and agreement purposes:   * DL-UL panel activation: activating L out of P available UE panel(s) at least for the purpose of DL reception and UL beam measurements (e.g. reception of DL source RS, transmission of SRS) * UL-data-Tx Panel switching: selecting 1 out of L activated UE panel(s) for the purpose of UL transmission   {Mod: The suggestion is in general fine but the purpose is to define ’short-hand’ terms and the proposed revision makes the terms longer  Also, the term ‘panel selection’ is used according to the WID. Lastly, the 2nd bullet is for UL transmission in general, not only data (in Rel.16 we discussed PUCCH, RACH, and some SRS). I modified the text to capture the good intention} |
| Huawei/HiSi2 | Proposal 4.1: We suggest updating ‘DL source RS’ as ‘DL measurement RS’.  {Mod: Agree, done} |
| MediaTek | Similar with Huawei, suggest to update “DL source RS” to “DL RS” or “DL measurement RS”.  In the last meeting, UE-initiated panel activation and selection are agreed in Rel-17, and NW-indicated panel activation and/or selection is still FFS.  **Agreement**  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.   From our understanding, if an UL panel is selected by a UE, NW can “confirm” the selection based on TCI activation to the UE. However, UL panel is still selected by the UE instead of NW.  We suggest to add a note under this proposal.  Note: UE-initiated panel activation and selection have been agreed in RAN#103-e  {Mod: Done, the reason I decided to keep it general after APT’s comment, for now, is because we have not ruled out NW-initiated approach}. |
| AT&T | Updated some views. Support the FL proposal |
| NTT Docomo2 | Support FL proposal. |
| LG | Inputs are updated in Table 8 and we are supportive on FL’s proposal 4.1.  For Issue 4.1, we are also fine with other alternatives if there’s a linkage between DL resources and UL resources which are for a same panel. |
| Xiaomi | Support the FL proposal. And we support NW initiate selection but not support NW initiate activation. |
| CMCC | We update our views in Table 8 and support FL proposal. |
| NEC | Fine with the proposal. |

### Issue 5 (MPE mitigation)

Table 10 Summary: issue 5

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| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 5.1 | Reporting of P-MPR report based on Rel.16 framework | Alternatives:   * **Not supported**: Ericsson * **Beam-level**: Intel (already supported by RAN2/RAN4 PHR MAC-CE), Apple, Qualcomm, ZTE OPPO (for each activated UL TCI state), Nokia/NSB * **Panel-level**: vivo, Sony, Spreadtrum, NTT Docomo, ZTE, Lenovo/MoM, Huawei/HiSi (2nd preference), IDC, APT, NEC |  |
| 5.2 | 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 | Alternatives:   * **Not supported**: vivo, OPPO, Huawei/HiSi, APT * **Beam-level (**with L1-RSRP/SINR**)**: Ericsson, Intel (without L1-RSRP/SINR), MTK, Apple, Qualcomm, NTT Docomo, ZTE, Nokia/NSB * **Panel-level (**with L1-RSRP/SINR**)**: Samsung, IDC, CATT, Xiaomi, LG   + **Alt1**: Samsung, Qualcomm, LG   + **Alt2**: Nokia/NSB, Sony, MTK (but not limited to MPE mitigation), Apple, Qualcomm, Xiaomi, ZTE, LG |  |
| 5.3 | Any additional reporting content:   * Alt0: no additional reporting content * Alt1: Additional reporting content | **Alt0**: Ericsson, Intel, Xiaomi, MTK, Spreadtrum, Lenovo/MoM, Huawei/HiSi, APT  **Alt1**:   * CRI/SSBRI + L1-RSRP/L1-SINR + P-MPR: OPPO, MediaTek, Nokia/NSB, IDC * CRI/SSBRI + L1-RSRP/L1-SINR + virtual PHR: Nokia/NSB, Apple, Convida,CMCC * CRI/SSBRI + L1-RSRP/L1-SINR + panel ID: LG,CMCC * CRI/SSBRI + virtual PHR: ZTE, Convida * CRI/SSBRI + UL RSRP + panel ID: Qualcomm * CRI/SSBRI + new/additional param. (indicating MPE): CMCC * P-MPR + panel-ID: vivo, Sony (panel-specific), IDC * P-MPR + alternative panel or UL TX beam: Nokia/NSB * ID of preferred/non-preferred panel: LGE |  |
|  |  |  |  |

**Proposal 5.1**:

Table 11 Additional inputs: issue 5

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| --- | --- |
| **Company** | **Input** |
| Intel | View are updated in Table 10 |
| MediaTek | Inputs updated in Table 8.  On Item 5.3, we see MPE-related reporting content is needed only when MPE issue has to be handled by NW instead of UE. However, if it is really needed, NW shall be able to estimate UL receive power of a beam pair link based on UE reporting of P-MPR and L1-RSRP corresponding to the beam pair link. |
| Apple | For MPE, we would like to share our view that the “unsafe” beam can still work with smaller bandwidth. So additional report can help gNB to identify the use case for the “unsafe” beam and “safe” beam. The Alt0 in 5.3 cannot be useful.  For issue 5.2, we assume the “beam level” means “gNB beam” instead of “UE beam”. From gNB perspective, gNB does not need to know which UE beam/panel is used, if the panels are only with different orientation angles. What gNB needs to know is the potential NW beam. |
| vivo | Some views included. |
| Xiaomi | We provided some views in Table 10. |
| Spreadtrum | Input updated |
| NTT Docomo | We would like to clarify the understanding of following issues.   * Whether the report of SSBRI/CRI in 5.2 is based on L1 beam reporting framework. * Whether the additional reporting content in 5.3 is additional to the reporting of PMPR report based on Rel.16 framework, or additional to the reporting of SSBRI/CRI in 5.2. |
| ZTE | Some more views are included.  On Item 5.3, UE reporting of P-MPR and L1-RSRP is not sufficient for gNB to estimate UL receive power in our views. It is due to the fact that gNB still can NOT be aware of “Pc,max” herein, which is defined as follows according to TS 38.331. In short, only a general range of “Pc,max” is specified (notes that it may also not be known for gNB considering CA/DC cases), and exact value is up to the UE implement. On contrary, PHR is defined according to an UL transmission, where all above complicated issues are well considered. |
| Ericsson | On 5.1: There is already P-MPR in the R16 framework – specified by RAN4/RAN2. Is the question if we should extend that? (I assume that in a sense the R16 reporting is already on panel level?)  5.2 & 5.3: is this one report? Would the report look like this:  Idx1 meas1  Idx2 meas2  Idx3 meas3  Idx4 meas4  And the discussion is what Idx and meas would be? On high level, Idx should also be in the TCI state, so that the gNB can control the transmission, and meas should be something that the gNB would use to select.  With this understanding, we think that Idx is SSBRI/CRI and meas is achievable UL SNR. |
| Nokia/NSB | Regarding 5.1 reporting of P-MPR, we prefer to clarify that it also includes early indication of potential MPE event.  As a response to MediaTek, we think MPR reduction would be required for certain direction or certain beans, or for a certain panel only. So it should be beneficial if gNB can understand the situation and avoid to index TCI causing MPR. |
| MediaTek | Response to ZTE, NW is still possible be aware of Pcmax based on PHR MAC-CE reported from UE?  Response to Nokia, we agree with that if UE reports a set of beams with different P-MPR values, it is beneficial to provide these values to gNB. However, if the MPE is detected in panel-level and UE still decides to activate the blocked panel for UL transmission, then UE will report a set of beams a large P-MPR value. Then, NW may still have to schedule UL transmission on these beams. |
| Huawei/HiSi | Added our views in table above. |
| InterDigital | Updated our view in the table. |
| APT | Add our views in the table. |
| ZTE2 | Response to Ericsson (R16 reporting is already on panel level?), the Rel-16 definition for P-MPE is still UE-specific according to our best knowledge. If required, we can send an LS to RAN4.  Response to MTK, since we are on the same page that Pcmax is necessary for estimating UL MPE impacts, straightforwardly all related parameters (e.g., Pcmax, PHR, CRI/SSBRI, etc) should be reported together in a reporting instance (e.g., reusing the framework of current Rel-16 PHR/P-MPR MAC-CE). |
| LG | Inputs are updated in Table 10. |
| CMCC | Update our views in the Table. |

### Issue 6 (beam refinement/tracking)

Table 12 Summary: issue 6

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| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 6.1 | Group 1: beam measurement/reporting via RACH for initial access (e.g. RO for measurement and MSG3 for reporting, impact of MPE mitigation) | Perform study and, if needed, specify:   * **Yes**: AT&T, Qualcomm, Nokia/NSB, Samsung, Xiaomi, Sony * **No**: OPPO, ZTE, Huawei/HiSi, Apple, vivo, Convida, Ericsson, Futurewei, LG, NEC |  |
| 6.2 | Group 2: faster joint DL TX and RX beam refinement/tracking (P2+P3) | Perform study and, if needed, specify:   * **Yes**: Apple (CSI-RS based), Samsung (CSI-RS based), Intel (using SRS/CRI), Nokia/NSB (P3 only), Futurewei * **No**: vivo, Qualcomm, Ericsson, Huawei/HiSi, LG |  |
| 6.3 | Group 3: Beam management with reduced DL signaling (e.g. beam update based on reporting, beam measurement and report triggered by beam indication, multi-SSB indication, semi-static beam switch) | Perform study and, if needed, specify:   * **Yes**: Futurewei, MTK, Samsung, OPPO, Apple, Intel, NTT Docomo, Qualcomm, Ericsson, IDC * **No**: vivo, Huawei/HiSi |  |
| 6.4 | Group 4: Reducing activation delay of TCI states (other WGs, e.g. RAN4) | Perform study and, if needed, specify:   * **Yes**: Ericsson, ZTE, Samsung, Apple (RAN1), vivo(RAN1), NTT Docomo, Futurewei (RAN4), Huawei/HiSi (send to RAN4) * **No**: |  |
|  |  |  |  |

**Proposal 6.1**:

Table 13 Additional inputs: issue 6

|  |  |
| --- | --- |
| **Company** | **Input** |
| Apple | For issue 6.4, I think from RAN1 perspective, we can support beam indication with AP-CSI-RS triggering to support fast beam refinement, so as to reduce action delay for TCI switching. This can be a RAN1 work. RAN4 can do something after RAN1 finished it. |
| Xiaomi | We provided some views in Table 12. |
| Sony | For 6.1, our preference added |
| Nokia/NSB | It would be beneficial for network to have knowledge from MP-UEs if there is a potential gain from P3 UE narrow beam alignment for each reported beam pair link (e.g. L1-RSRP) for enhancing beam management for MP-UEs with panels of e.g. different capabilities (array gain, EIRP) or seeing sufficiently different environments. We would like to to enable faster P3 UE beam refinement while reducing overhead (e.g. considering cases of antenna scaling and/or refinement ability on UE serving and candidate beams) |
| Futurewei | Our views are updated in the table above. |
| Huawei/HiSi | Added our views in table above. |
| InterDigital | Updated our view in the table. |
| LG | Inputs are updated in Table 12. |
|  |  |

## Appendix A: Agreements in RAN1#102-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

**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

**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

**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.

**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

# References

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | R1-2100044 | Enhancement on multi-beam operation | FUTUREWEI |
| 2 | R1-2100063 | Discussions on Rel-17 Beam Management | InterDigital, Inc. |
| 3 | R1-2100118 | Enhancements on Multi-beam Operation | OPPO |
| 4 | R1-2100208 | Enhancements on multi-beam operation | Huawei, HiSilicon |
| 5 | R1-2100273 | Enhancements on Multi-beam Operation | Lenovo, Motorola Mobility |
| 6 | R1-2100285 | Enhancements on Multi-beam Operation | ZTE |
| 7 | R1-2100343 | Enhancements on multi-beam operation | CATT |
| 8 | R1-2100421 | Further discussion on multi beam enhancement | vivo |
| 9 | R1-2100534 | Enhancements on multi-beam operation | Fraunhofer IIS, Fraunhofer HHI |
| 10 | R1-2100588 | Enhancement on multi-beam operation | MediaTek Inc. |
| 11 | R1-2100618 | Enhancements on Multi-beam Operation | LG Electronics |
| 12 | R1-2100636 | Enhancements to Multi-Beam Operations | Intel Corporation |
| 13 | R1-2100737 | Enhancements on Multi-beam Operation | Fujitsu |
| 14 | R1-2100779 | Enhancements on multi-beam operations | AT&T |
| 15 | R1-2100783 | Enhancements on Multi-beam Operation | Spreadtrum Communications |
| 16 | R1-2100844 | Further enhancement on multi-beam operation | Sony |
| 17 | R1-2100949 | Discussion on multi-beam operation | NEC |
| 18 | [R1-2100964](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100964.zip) | Discussion on Enhancements for Multi-beam Operation | Asia Pacific Telecom, FGI |
| 19 | [R1-2101005](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101005.zip) | Enhancements on Multi-beam Operation | Nokia, Nokia Shanghai Bell |
| 20 | [R1-2101023](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101023.zip) | Discussion on multi-beam operation | ASUSTeK |
| 21 | [R1-2101032](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101032.zip) | Enhancements on multi-beam operation | CMCC |
| 22 | [R1-2101092](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101092.zip) | Enhancements on multi-beam operation | Xiaomi |
| 23 | [R1-2101186](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101186.zip) | Multi-Beam Enhancements | Samsung |
| 24 | [R1-2101313](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101313.zip) | Enhancements on Multi-beam Operation | Ericsson |
| 25 | [R1-2101350](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101350.zip) | Views on Rel-17 Beam Management enhancement | Apple |
| 26 | [R1-2101414](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101414.zip) | Multi-beam Enhancements | Convida Wireless |
| 27 | [R1-2101446](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101446.zip) | Enhancements on Multi-beam Operation | Qualcomm Incorporated |
| 28 | [R1-2101597](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101597.zip) | Discussion on multi-beam operation | NTT DOCOMO, INC. |
| 29 | [R1-2101644](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101644.zip) | Enhancements on Multi-Beam Operation | TCL Communication Ltd |
| 30 | [R1-2101193](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101193.zip) | Additional enhancements for multi-beam | Samsung |
| 31 | [R1-2101318](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101318.zip) | Additional simulation results on multi-beam operation | Ericsson |