**3GPP TSG RAN WG1 #104-e R1-210xxxx**

**e-Meeting, January 25th – February 5th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#2 for multi-beam enhancement: Round 1

**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 |

## Summary and proposals

The summary and proposals are based on the content of the first FL summary R1-2101185.

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

Table 1 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 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 |  |
| 1.11 | TCI State pool for CA  Alt1: Shared among CCs  Alt2: Individually configured per CC | **Alt1 (14)**: Spreadtrum, Xiaomi, ZTE, vivo, MTK, Intel, Sony, NTT Docomo, Samsung, Qualcomm, Lenovo/MoM, Ericsson (UL TCI), IDC  **Alt2 (12)**: 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 (11)**: Spreadtrum, Xiaomi, ZTE, CATT, vivo, MTK, Intel, Convida, Qualcomm, Samsung, NTT Docomo  **Alt2 (15)**: Futurewei, OPPO, Lenovo/MoM, Nokia/NSB, CMCC, Ericsson, Huawei/HiSi, AT&T, Sony, Lenovo/MoM, APT |  |

**Proposal 1.1**: On Rel.17 unified TCI framework:

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

**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 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, e.g. whether dedicated L1 signaling is needed for the dynamic switching
* 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, decide by RAN1#104bis-e:

* Whether DL TCI also applies to the following:
  + CSI-RS resources for CSI
  + Some CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)
  + CSI-RS for tracking
* Whether DL TCI also applies to the following:
  + Some SRS resources or resource sets for BM

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

* When an UL RS is in the UL TCI state, reuse Rel-16 PL-RS framework
* When a DL RS is in the UL TCI state, select one of the following alternatives by RAN1#104bis-e:
  + Alt1. PL-RS is included in UL TCI state
  + Alt2. PL-RS is associated with (but not included in) UL TCI state

**Proposal 1.5**: On Rel.17 unified TCI framework:

* The setting of UL PC parameters is at least associated with UL channel
* Select one of the following alternatives by RAN1#104bis-e:
  + Alt1. The setting of UL PC parameters is also associated with UL TCI state
  + Alt2. The setting of UL PC parameters is not associated with UL TCI state

Table 2 Inputs: issue 1

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| **Company** | **Input** |
| Moderator | 1.1: Including Xi’s edit. Re Intel’s and LG’s comment on separate DL/UL, UL TX spatial filter reference has been defined in previous agreements, especially in RAN1#103-e:   * *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*   The pool design for separate DL/UL TCI should not cause a new definition of UL TCI.  Re applicability of QCL Type-D to FR1/FR2 vs FR2 only, this proposal doesn’t address this. Note that this was already agreed in RAN1#102-e:  *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*   1.2: Not yet discussed in GTW, but stable  1.3: Just as the source RS issues, we need to conclude this by RAN1#104bis-e  1.4/1.5: Based on the summary in issue 1.6/1.7, this is a reasonable starting point. Please note we need to narrow down alternatives in this meeting for better decision making in the next meeting. |
| Qualcomm | For Proposal 1.1   * The previous agreement seems only mentioned for UL TCI. This proposal is for joint TCI, i.e. whether its QCL-TypeD can determine UL spatial filter in FR1. But we are fine to discuss this later.   For Proposal 1.3   * For the 2nd bullet, our understanding is that DL TCI cannot be applied to UL signal. Not sure if we really understand the proposal.   For Proposal 1.4   * For the 2nd bullet, same issue should also exist for joint TCI state. Suggest to replace “UL TCI state” with “UL and joint TCI state”   For Proposal 1.5   * For both bullets, “UL PC parameters” might be replaced with “UL PC parameters except for PL RS”, since PL RS is discussed in Proposal 1.4 * For the 2nd bullet, same issue should also exist for joint TCI state. Suggest to replace “UL TCI state” with “UL and joint TCI state” |
| Apple | Support proposal 1.1  Support proposal 1.2. We think either Alt1 or Alt3 should be fine. Alt2 may have a problem if network chooses a joint TCI but MPE happens. Network may need to decide whether to scarify DL performance or UL performance.  Support proposal 1.3, our understanding is that we may need a 3rd QCL indication for QCL-TypeB or QCL-TypeC if CSI-RS is included.  For proposal 1.4, I am not sure whether I misunderstood anything, but I think if DL RS is included in TCI, this RS can be used for pathloss calculation. Should it be modified as follows?  **Proposal 1.4**: On Rel.17 unified TCI framework:   * When a DL RS is in the UL TCI state, reuse Rel-16 PL-RS framework * When an UL RS is in the UL TCI state, select one of the following alternatives by RAN1#104bis-e:   + Alt1. PL-RS is included in UL TCI state   + Alt2. PL-RS is associated with (but not included in) UL TCI state   Support proposal 1.5 |
| Futurewei | Proposal 1.1: Support the proposal.  Proposal 1.2: Ok. We support Alt. 1.  Proposal 1.3: Support the proposal.  Proposal 1.4: Ok. On the second bullet, we support Alt. 2.  Proposal 1.5: Ok. On the second bullet, we support Alt. 1. |
| OPPO | Proposal 1.1: support  Proposal 1.2: we do not support Alt.2  Proposal 1.3: support.  Proposal 1.4: We suggest to make the following change.  **Proposal 1.4**: On Rel.17 unified TCI framework:   * When an DL RS is in the UL TCI state, the DL RS is used as the PL RS * When a UL RS is in the UL TCI state, select one of the following alternatives by RAN1#104bis-e:   + Alt1. PL-RS is included in UL TCI state   + Alt2. PL-RS is associated with (but not included in) UL TCI state   The issue for “reuse rel-16 PL RS framework” is it does not work for unified TCI framework. The PL RS shall be associated with UL Tx beam In Rel16, the pathloss RS for PUSCH is associated with SRI codepoints. But in unified TCI framework, the SRI codepoint will not be associated with UL Tx beam. Therefore, we have to change the design to associated PL RS with UL TCI state.  Proposal 1.5: We believe whether UL PC parameter shall be associated with UL TCI state shall be decided for each of PUSCH, PUCCH and SRS separately. For that in our view, we shall reuse the rel15/rel16 design: for PUSCH and PUCCH, the UL PC parameters shall be associated with each UL TCI state too, but for SRS, the UL PC parameters is only associated with each SRS resource set.  Thus suggest to change proposal 1.5 as follows. Furthermore, it is suggested to list the PC parameters clearly here.  **Proposal 1.5**: On Rel.17 unified TCI framework:   * The setting of UL PC parameters (P0, alpha, closed loop index) is at least associated with UL channel * Select one of the following alternatives by RAN1#104bis-e for PUSCH, PUCCH and SRS separately:   + Alt1. The setting of UL PC parameters (P0, alpha, closed loop index) is also associated with UL TCI state   + Alt2. The setting of UL PC parameters (P0, alpha, closed loop index) is not associated with UL TCI state |
| Samsung | Support proposal 1.1. Agree that UL spatial filter for separate UL TCI state is already covered by the RAN1#103-e agreement.  Proposal 1.2 is fine, we can most probably combine Alt1 and Alt3 as DCI and MAC CE can be viewed as different design options for dynamic signaling.  Support proposal 1.3.  Don’t support 1.4.   * In general, it is desirable to have the same framework whether DL-RS or UL-RS is included in the TCI state. * There are three cases to consider:   + TCI state has a periodic DL source RS 🡺 PL-RS is a periodic DL source RS   + TCI state has an aperiodic DL source RS 🡺 PL-RS is a periodic DL RS that is QCLed (TypeD) with the aperiodic DL source RS   + TCI state has an UL source RS 🡺 PL-RS is a periodic DL RS that is QCLed (TypeD) with the UL source RS * Proposal 1.4 should apply for UL TCI state, as well as joint DL/UL TCI state (else there should be an FFS for joint DL/UL TCI state).   Updated proposal:  **Proposal 1.4**: On Rel.17 unified TCI framework:   * When an UL RS is in the UL TCI state or Joint DL/UL TCI State, select one of the following:   + Alt1: reuse Rel-16 PL-RS framework   + Alt2: a DL periodic RS that is a source reference signal for the UL RS * When a DL RS is in the UL TCI state or Joint DL/UL TCI State, select one of the following alternatives by RAN1#104bis-e:   + Alt1. PL-RS is included in UL TCI state   + Alt2. PL-RS is associated with (but not included in) UL TCI state   + Alt 3: A DL periodic source RS of QCL TypeD included in the TCI state, or a DL periodic RS TypeD-QCLed with a source RS of QCL TypeD   For proposal 1.5, we suggest the following update:  **Proposal 1.5**: On Rel.17 unified TCI framework:   * The setting of UL PC parameters is at least associated with UL channel * Select one of the following alternatives by RAN1#104bis-e:   + Alt1. The setting of UL PC parameters is also associated with UL TCI state or joint DL/UL TCI state.   + Alt2. The setting of UL PC parameters is not associated with UL TCI state or joint DL/UL TCI state.   + Alt3. The setting of the UL PC parameters is also included in UL TCI state or joint DL/UL TCI state. |
| MediaTek | Proposal 1.1: Support this proposal. Applicability of joint DL/UL TCI for UL in FR1 could be discussed later even we think it should be aligned with separate UL TCI in FR1.  Proposal 1.2: Support.  Proposal 1.3: Support but the TCI applied to SRS should be UL not DL.  Proposal 1.4: Sorry we are a bit confused on this proposal.   * When a DL RS is included in an UL TCI state (as a source RS), does Alt1 mean the DL RS is used as a PL-RS or a separate RS will be configured in the UL TCI as PL-RS? * When an UL RS is included in an UL TCI state (as a source RS), we don’t see the reason to reuse Rel-16 framework, at least this may not work well in many cases.   We suggest the following update:  **Proposal 1.4**: On Rel.17 unified TCI framework:   * When the source RS for determining spatial Tx filter in the UL TCI state is a periodic CSI-RS or an SSB, select one of the following alternatives by RAN1#104bis-e:   + Alt1. The source RS is used as PL-RS   + Alt2. The source RS is used as PL-RS, if no PL-RS is included in/associated with the UL TCI state * When the source RS for determining spatial Tx filter in the UL TCI state is neither a periodic CSI-RS nor an SSB, select one of the following alternatives by RAN1#104bis-e:   + Alt1. PL-RS is included in UL TCI state   + Alt2. PL-RS is associated with (but not included in) UL TCI state   Proposal 1.5: Support |
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### Issue 2 (L1/L2-centric inter-cell mobility)

**Proposal 2.1**: On Rel.17 enhancements for L1/L2-centric inter-cell mobility:

* Intra-DU only is assumed (i.e. no inter-DU)
* The following issues will be discussed in RAN2 (FL to send an LS to RAN2 when the time comes):
  + Whether RRC reconfiguration is needed
  + Whether a change in serving cell can occur
  + Whether C-RNTI can change

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

* A 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 3 Inputs: issue 2

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| **Company** | **Input** |
| Moderator | 1.1: Not yet discussed in GTW, but stable. Also added the more controversial RAN2-specific issues in the second bullet. Note that the inter-DU will require not only RAN2, but also RAN3   * Implication: RAN1 can focus on completing measurement/reporting and QCL issues   1.2: Not yet discussed in GTW, but stable |
| Qualcomm | For Proposal 2.1   * For 2nd bullet, suggest to add “Whether a serving cell can be configured with multiple PCIs” in the list for RAN2 to decide. The benefit is that UE can completely move outside the coverage of one PCI without serving cell change. * Suggest to add a new 3rd bullet on FFS whether same or different TA is assumed across different PCIs at least for single TRP operation. This is an important assumption to clarify as well   For Proposal 2.2   * For the last FFS, is “Activation/deactivation for the CSI-reportConfig” done by MAC-CE? Good to clarify the meaning |
| Apple | Support both proposals.  For proposal 2.2, to reply Qualcomm’s question, I think the answer should be yes. |
| Futurewei | Proposal 2.1: Support the proposal.  Proposal 2.2: Support the proposal. |
| OPPO | Proposal 2.1: support and suggest to add the following FFS point.  **Proposal 2.1**: On Rel.17 enhancements for L1/L2-centric inter-cell mobility:   * Intra-DU only is assumed (i.e. no inter-DU) * The following issues will be discussed in RAN2 (FL to send an LS to RAN2 when the time comes):   + Whether RRC reconfiguration is needed and if needed, what information would be included in the minimum RRC reconfiguration, for example PCI of target cell, RRM configuration, minimum system information, etc.   + Whether a change in serving cell can occur   + Whether C-RNTI can change   Proposal 2.2: we are not ok with the last FFS sub-bullet. “CSI-reportConfig” is used in L1 CSI/BM measurement and report. Adding such a FFS point implies we are going to support L1 measurement. We prefer to resuse L3-RSRP measurement. Suggest to delete it.  **Proposal 2.2**: On Rel.17 multi beam measurement/reporting enhancements:   * A 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: Whether beam reporting associated with non-serving cell(s) can be mixed with that with serving-cell in one reporting instance |
| Samsung | Support proposal 2.1  Support proposal 2.2 |
| MediaTek | Proposal 2.1: Support  Proposal 2.2: Support. However, on the fifth sub-bullet, we don't quite understand why we need this FFS. A CSI report setting can be either activated/deactivated by MAC-CE if it is SP reporting, or dynamically triggered by DCI if it AP reporting. If this feature will be a part of CSI framework then this functionality will be naturally supported. Or, are we going to re-design CSI framework for this feature? |
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### Issue 3 (beam indication signaling medium)

Table 4 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) (7):** Spreadtrum, Xiaomi, Ericsson, CATT, MTK, NEC, Samsung  **Alt2 (ACK) (17):** 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) (21):** IDC, Fujitsu, Nokia/NSB, Xiaomi, Ericsson, Apple, ZTE, CATT, vivo, MTK, Intel, Qualcomm, NTT Docomo, Samsung, Sony, Spreadtrum, Lenovo/MoM, LG, NEC  **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) |
| 3.4 | 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 (18)**: 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 (4)**: Ericsson, Huawei/HiSi, LG   DCI formats 0\_1/0\_2 with UL grant:   * **Yes (10)**: IDC, Nokia/NSB, Xiaomi (at least for UL-only TCI), ZTE (at least for UL-only TCI), MTK, LGE, Intel, Sony (Study), Qualcomm * **No (12)**: 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 (15)**: 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 (8)**: Ericsson, MTK, Convida, Apple, vivo, Huawei/HiSi, LG   **Support extending existing DCI formats for UL-only TCI**: APT |  |

**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

**Proposal 3.2**: On the beam application time for Rel.17 DCI-based beam indication, support (cf. the definition of Alt1 and Alt2 as agreed in RAN1#102-e):

* Alt1 (defined after DCI reception) for PDSCH reception associated with the DCI that signals the TCI state update
  + DCI-to-PDSCH time gap is determined by UE capability beamSwitchTiming (BST) analogous to Rel.15/16
* Alt2 (defined after acknowledgment transmission) for other channels/signals

**Proposal 3.3**: On the beam application time for Rel.17 DCI-based beam indication:

* Support using DCI formats 1\_1 and 1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI
  + Support DCI acknowledgment mechanism based on SPS PDSCH release
* No other additional DCI format is supported in Rel.17

Table 5 Inputs: issue 3

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| **Company** | **Input** |
| Moderator | 3.1: Not yet discussed in GTW, but stable  3.2: Considering the pros and cons of Alt1 and Alt2, the proposal from LG could be a good starting point for compromise.  3.3: We need to close the DCI format issue as soon as possible since there are detailed issues. Given the situation (pros and cons, as well as supporting companies) summarized in issue 3.4 (table), this is a good compromise. |
| Qualcomm | For Proposal 3.1   * Suggest to add one FFS: the application time when DCI and applied channel(s) are on different CCs   For Proposal 3.2   * We do not support it. We can discuss either after DCI or after ACK for all channels, even fine for majority view. But we highly NOT prefer that some channels are after DCI and some channels are after ACK. UE has to maintain two application time for the TCI update. This will unnecessarily complicate the implementation. |
| Apple | Support proposal 3.1  We have similar concern as Qualcomm for proposal 3.2. we suggest a unified timing.  For proposal 3.3, we support the general idea and suggest an FFS on how to differentiate beam indication and SPS release as follows:  **Proposal 3.3**: On the beam application time for Rel.17 DCI-based beam indication:   * Support using DCI formats 1\_1 and 1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI   + Support DCI acknowledgment mechanism based on SPS PDSCH release   + FFS: how to differentiate DCI for beam indication and DCI for SPS PDSCH release * No other additional DCI format is supported in Rel.17 |
| Futurewei | Proposal 3.1: Support the proposal.  Proposal 3.2: Need further discussions on the potential added UE complexity.  Proposal 3.3: Not support the proposal. Additional DCI format should be considered in Rel. 17. |
| OPPO | Proposal 3.1: support  Proposal 3.2: we do not support.  First of all, we do not support to apply different application time on different channels/signals. That is not right technically. We shall apply a single application time on all the channels/signals in the scope of unified common TCI.  Secondly, we think both the time location of DCI and ACK shall be included in application time because either one of them consider the time requirement from UE or 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.   So suggest to change proposal 3.2 to:  **Proposal 3.2**: On the beam application time for Rel.17 DCI-based beam indication, the beam application time is the first slot that meet both conditions   * at least X1 ms or Y1 symbols after the DCI with beam indication * at least X1 ms or Y2 symbols after the acknowledgment for the beam indication   Regarding proposal 3.3: we support in general. |
| Samsung | Support proposal 3.1  OK with proposa1 3.2, to clarify that this is not a down-selection of alt1 and alt2, we suggest the following small update:  **Proposal 3.2**: On the beam application time for Rel.17 DCI-based beam indication, support both of (cf. the definition of Alt1 and Alt2 as agreed in RAN1#102-e):   * Alt1 (defined after DCI reception) for PDSCH reception associated with the DCI that signals the TCI state update   + DCI-to-PDSCH time gap is determined by UE capability beamSwitchTiming (BST) analogous to Rel.15/16 * Alt2 (defined after acknowledgment transmission) for other channels/signals   Regarding proposal 3.3, our first preference is to support a dedicated DCI format for beam indication with ACK mechanism without any additional unnecessary overhead (including without DL assignment/UL grant) and without increasing the number of blind decodes (therefore the payload will be matched to one of the existing DCI formats a UE is required to search).  Note that DCI formats 1\_1 and 1\_2 are defined in 38.212 as “used for the scheduling of PDSCH in one cell”, implying that DL assignment is present. So the FL proposal “Support using DCI formats 1\_1 and 1\_2 without DL assignment” needs the following clarification:   * Does the resulting payload size match the original DCI formats 1\_1/1\_2 (with DL assignment)? * Compared to a newly designed (optimized) dedicated DCI, what are the advantages of reusing DCI formats 1\_1/1\_2 without DL assignment? |
| MediaTek | Proposal 3.1: Support.  Proposal 3.2: We have a strong concern on this proposal since UE is required to maintain to two different timelines. Prefer a unified application time in this unified TCI framework, either measured from DCI reception or measured from HARQ-ACK transmission.  Proposal 3.3: Support Moderator’s suggestion and this proposal. Share similar view with Apple that validation manner should be defined later, update based on Apple’s revision on the FFS part:   * + FFS: how to differentiate a DCI format 1\_1 or 1\_2 without DL assignment is used for beam indication rather than indicating SPS PDSCH release or SCell dormancy |

### Issue 4 (MP-UE)

Table 6 Summary: issue 4

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **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 |  |

**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

**Proposal 4.2**: On Rel.17 enhancements to facilitate UL beam selection for MP-UE, a ‘panel’ constitutes a group of antenna ports.

* [Relation with, e.g. CSI-RS resource set, SRS resource set]

Table 7 Inputs: issue 4

|  |  |
| --- | --- |
| **Company** | **Input** |
| Moderator | 4.1: Not yet discussed in GTW, but stable  4.2: Apple’s proposal is a good starting point, but so far supported only by 4 companies. I’d appreciate of other companies can comment on the proposal and build on it. |
| Qualcomm | We are fine for both Proposal 4.1 and 4.2 |
| Apple | Support proposal 4.1 and 4.2 |
| OPPO | Proposal 4.1: do not support. Recalling the discussion in rel16, we spent much time and effort discussing the “panel”. And now it looks like we are repeating the same discussion again. In the system, the system only indicates some UL TCI state or spatial relation info to the UE for determining UL Tx beam. How to choose a Tx beam or panel is up to UE implementation. Panel activation or panel selection is also part of UE implementation. We do not see the reason why we will discuss something that will not have impact on spec.  Proposal 4.2: do not support. The beam selection in FR2 is not related with antenna ports. For instance, we can apply different Tx beams (i.e., different UL TCI state) on different PUSCH transmission but we still use the antenna ports on those PUSCH transmission. Same for SRS and PUCCH. |
| Samsung | Support proposal 4.1  OK with proposal 4.2. |
| MediaTek | It is good to have conclusions to align the understanding on the terminologies. Note that these terminologies are already used in the previous agreements.  Support proposal 4.1 as a conclusion since there is no spec impact.  **Agreement**  [Issue 4] For Rel.17 NR FeMIMO, on MP-UE assumption to facilitate fast UL panel selection:   * 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   On proposal 4.2, we are not sure whether it is needed. We already agreed on some assumptions on UE panel in RAN1#102e, including how the antenna ports, beams, and TXRUs map to a UE panel. |

### Issue 5 (MPE mitigation)

Table 8 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 (7)**: Intel (already supported by RAN2/RAN4 PHR MAC-CE), Apple, Qualcomm, ZTE OPPO (for each activated UL TCI state), Nokia/NSB * **Panel-level (12)**: 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**) (9)**: Ericsson, Intel (without L1-RSRP/SINR), MTK, Apple, Qualcomm, NTT Docomo, ZTE, Nokia/NSB * **Panel-level (**with L1-RSRP/SINR**) (12)**: 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**: On Rel.17 enhancements to facilitate MPE mitigation,

* On P-MPR report based on Rel.16 framework, decide in RAN1#104bis-e whether to focus study on either beam-level or panel-select reporting
* On SSBRI(s)/CRI(s) and/or indication of panel selection for the purpose of indicating, decide in RAN1#104bis-e whether to focus study on either of the following:
  + Beam-level reporting of feasible UL TX beam(s) for UL transmission taking the MPE effect into account, with companion L1-RSRP/SINR
  + Panel-level reporting of feasible UE panel(s) for UL transmission taking the MPE effect into account, with companion L1-RSRP/SINR

Table 9 Inputs: issue 5

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| --- | --- |
| **Company** | **Input** |
| Moderator | 5.1: We need to start narrowing down options for study. From the summary, this could be a good starting point |
| Qualcomm | Support Proposal 5.1 |
| Apple | Support proposal 5.1 |
| OPPO | Ok with Proposal 5.1 |
| Samsung | Support proposal 5.1 |
| MediaTek | Support proposal 5.1 in principle. However, in the last meeting, multiple use cases are agreed for Rel-17 MP-UE, and MPE mitigation is one of them. The solution we have in the end should be unified. Therefore, for the second sub-bullet, as a new feature introduced for Rel-17 MP-UE, we prefer not to limit the use case and suggest the following update:  **Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation,   * On P-MPR report based on Rel.16 framework, decide in RAN1#104bis-e whether to focus study on either beam-level or panel-select reporting * On SSBRI(s)/CRI(s) and/or indication of panel selection for the purpose of indicating, decide in RAN1#104bis-e whether to focus study on either of the following:   + Beam-level reporting of feasible UL TX beam(s) for UL transmission at least taking the MPE effect into account, with companion L1-RSRP/SINR   + Panel-level reporting of feasible UE panel(s) for UL transmission at least taking the MPE effect into account, with companion L1-RSRP/SINR |

### Issue 6 (beam refinement/tracking)

Table 10 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**: On Rel.17 enhancements based on the unified TCI framework, perform study and, if needed, specify the following:

* 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)
* Reducing activation delay of TCI states (including other WGs, e.g. RAN4)

Table 11 Inputs: issue 6

|  |  |
| --- | --- |
| **Company** | **Input** |
| Moderator | 6.1: Based on the views on companies, this could be a good starting point for issue 6 |
| Qualcomm | For Proposal 6.1   * For 2nd bullet, to be aligned, can someone explain the issue and corresponding RAN4 LS if any? Cannot find any description in previous summary. To our understanding, all LSs are under discussion in other sessions. We prefer to remove 2nd bullet if the motivation is unclear. |
| Apple | Support proposal 6.1 |
| Futurewei | We are in general ok with Proposal 6.1. On the second bullet “Reducing activation delay of TCI states”, this item should be performed by RAN4, instead of RAN1. So we suggest removing this bullet. |
| Samsung | Support proposal 6.1 |
| MediaTek | Support proposal 6.1 with adding one example:  **Proposal 6.1**: On Rel.17 enhancements based on the unified TCI framework, perform study and, if needed, specify the following:   * 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, UE-initiated beam update/activation) * Reducing activation delay of TCI states (including other WGs, e.g. RAN4) |