**3GPP TSG RAN WG1 #110 R1-220nnnn**

**Toulouse, France, August 22nd – 26th, 2022**

**Agenda item:** 9.1.1.1

**Source:** Moderator (MediaTek)

**Title:** Moderator summary on extension of unified TCI framework (Round 0)

**Document for:** Discussion and Decision

# Introduction

In RAN#94e, the Rel-18 WID of MIMO evolution for downlink and uplink is approved [1]. In the approved WID, extension of unified TCI framework is a part of the RAN1 objectives, and the detailed scope of this agenda item (Item 1A) includes the following highlighted objectives:

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| **RAN1:**   1. Specify extension of Rel-17 Unified TCI framework for indication of multiple DL and UL TCI states focusing on multi-TRP use case, using Rel-17 unified TCI framework. 2. Study, and if needed, specify the following items to facilitate simultaneous multi-panel UL transmission for higher UL throughput/reliability, focusing on FR2 and multi-TRP, assuming up to 2 TRPs and up to 2 panels, targeting CPE/FWA/vehicle/industrial devices (if applicable)    * UL precoding indication for PUSCH, where no new codebook is introduced for multi-panel simultaneous transmission      + The total number of layers is up to four across all panels and total number of codewords is up to two across all panels, considering single DCI and multi-DCI based multi-TRP operation.    * UL beam indication for PUCCH/PUSCH, where unified TCI framework extension in objective 2 is assumed, considering single DCI and multi-DCI based multi-TRP operation      + For the case of multi-DCI based multi-TRP operation, only PUSCH+PUSCH, or PUCCH+PUCCH is transmitted across two panels in a same CC. 3. Study, and if justified, specify the following    * Two TAs for UL multi-DCI for multi-TRP operation    * Power control for UL single DCI for multi-TRP operation where unified TCI framework extension in objective 2 is assumed.   For the case of simultaneous UL transmission from multiple panels, the operation will only be limited to the objective 6 scenarios. |

Based on the contributions from companies [2]-[33], the followings are provided in this document:

* Summary of companies’ views on each of open issues raised by interested companies, where the open issues are categorized as follow:
  + Issue 1 – General framework for unified TCI extension
  + Issue 2 – TCI state update and activation
  + Issue 3 – How to associate the indicated TCI state(s) with each target channel/signal
  + Issue 4 – UL power Control for UL MTRP
  + Issue 5 – Beam reporting and beam failure recovery
* Observations and recommended proposals based on the summary of companies’ views

# Issue 1 – General framework for unified TCI extension

Open issues on general framework for unified TCI extension and company views are summarized below.

Table 1-1 Summary for Issue 1

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| **#** | **Issue** | **Companies’ views** | **FL note/observation** |
| 1.1 | Whether multiple joint/DL TCI states can be applied simultaneously to CJT-based PDSCH reception(s) | Support: Google, Ericsson, Docomo, ZTE (in principle), Lenovo, Intel (in principle), FGI, Huawei/HiSilicon, CMCC, Samsung  Concern: vivo, NEC, Fujitsu, IDC, Apple, Spreadtrum, Qualcomm (ok for SFN)  Out-of-scope: OPPO, Fraunhofer | Proposal 1.A is provided for this issue  Note that even applying two TCI states for CJT is not supported in current spec. In current spec, UE is required to assume that the PDSCH DM-RS port(s) is QCLed with the DL RSs of two TCI states only for PDSCH-SFN. Thus, this issue must be discussed and decided first before further considering the max number of TCI states for CJT in unified TCI extension. On the other hand, this issue may or may not be out of the Rel-18 MIMO scope. |
| 1.2 | Up to four TCI states can applied in a CC/BWP, including the following possible combinations:   * 2 joint TCI states * 2 pairs of DL and UL TCI states * 1 pair of DL and UL TCI states + 1 DL TCI state * 1 pair of DL and UL TCI states + 1 UL TCI state * FFS: 3 joint TCI states * FFS: 4 joint TCI states * FFS: 1 joint TCI state + 1 pair of DL and UL TCI states * FFS: 1 joint TCI state + 1 DL TCI state * FFS: 1 joint TCI state + 1 UL TCI state | Support: OPPO (not for more than 2 joint TCI states)  Concern: | Proposal 1.B is provided for this issue  Note that we don't discuss whether to consider CJT in unified TCI extension in this issue, which should be decided in Issue 1.1. If Proposal 1.A can be agreed, then these combinations of TCI states (w/o FFS) are naturally supported for CJT, and this group can further discuss whether to support {3 joint TCI states}, {4 joint TCI states}, and other combination(s) for CJT use case. |
| 1.3 | Support joint DL/UL TCI update and separate DL/UL TCI update in a same CC/BWP simultaneously | Support: Intel, FGI, Huawei/HiSilicon, QC, CATT, CMCC, ITRI, Panasonic, TCL, vivo, Xiaomi  Concern: Google, OPPO, Lenovo, LG, Spreadtrum, Nokia, MediaTek, Fraunhofer | Some corresponding combinations are added for FFS in Proposal 1.B for this issue  Based on the offline discussion (please check Appendix B), for proponents of the individual TCI update modes for two TRPs in the same CC/BWP, the main use case is that there could be only one of the TRPs suffering from MPE issue. Opponents can further clarify how to handle such case if the individual TCI update modes in the same CC/BWP are not allowed. |
| 1.4 | RRC-configured TCI state lists | Alt1-Reuse Rel-17 design (i.e., one list for joint/DL TCI states and another list for UL TCI states): Apple (S-DCI), Ericsson, CATT (S-DCI), Fujitsu, Panasonic, MediaTek, QC, OPPO  Atl2-Introduce TRP-specific TCI state list(s): Apple (M-DCI), CATT (M-DCI), ZTE, Spreadtrum, TCL, Google | If no consensus can be reached in this issue, then Alt1 will be the natural outcome |
| 1.5 | Introduction of TRP-ID/index associated with or included in each TCI state | Support: CMCC  Concern: Ericsson, MediaTek, Apple, Docomo, Nokia, CATT, OPPO, LG, Intel |  |

**Proposal 1.A**: On unified TCI framework extension, more than one joint/DL TCI states can be applied simultaneously to CJT-based PDSCH reception, i.e., the UE shall assume that every PDSCH DM-RS port is QCLed with the DL RSs of the more than one joint/DL TCI states

* FFS: The maximum number of joint/DL TCI states that can be applied simultaneously for CJT-based PDSCH reception(s)

**Proposal 1.B**: On unified TCI framework extension, up to 4 TCI states can be applied in a CC/BWP, where these TCI states are indicated/ updated by MAC-CE/DCI with the necessary MAC-CE based TCI state activation

* One of the following combinations can be applied in a CC/BWP for MTRP operation:
  + 2 joint TCI states
  + 2 pairs of DL and UL TCI states
  + 1 pair of DL and UL TCI states + 1 DL TCI state
  + 1 pair of DL and UL TCI states + 1 UL TCI state
  + [1 pair of DL TCI states]
  + FFS: 3 DL TCI states
  + FFS: 4 DL TCI states
  + FFS: 1 joint TCI state + 1 pair of DL and UL TCI states
  + FFS: 1 joint TCI state + 1 DL TCI state
  + FFS: 1 joint TCI state + 1 UL TCI state
  + Note: 1 joint TCI state is already supported by Rel-17 unified TCI framework
  + Note: 1 pair of DL and UL TCI states is already supported by Rel-17 unified TCI framework

Table 1-2 Additional inputs for Issue 1

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| **Company** | **Input** |
| Mod V00 | **Please update your view on those sub-issues in Table 1-1 and check above moderator proposals** |
| QC | For 1.A, as elaborated in last round, it seems only sensible to map the same set of TCI(s) to every PDSCH DMRS port, since every stream is precoded across ALL TRPs in CJT. This can be viewed as extension of R17 SFN PDSCH potentially with > 2 TCIs if it is agreed. So we suggest the following changes to make this clear.  **Proposal 1.A**: On unified TCI framework extension, more than one joint/DL TCI states can be applied simultaneously to CJT-based PDSCH reception, i.e., the UE shall assume that ~~the~~ every PDSCH DM-RS port~~(s)~~ is QCLed with the DL RSs of the ~~two~~ more than one joint/DL TCI states   * FFS: The maximum number of joint/DL TCI states that can be applied simultaneously for CJT-based PDSCH reception(s)   [Mod] Fixed! Yes, the behavior is the same as SFN to my understanding, and I just copied the same wording from current spec for SFN in this proposal for CJT. However, the revised wording looks more clear.  For 1.B, suggest to add 2 DL TCIs in the list. Only 1 activated/indicated DL TCI is allowed in R17 as in 214. Also, the use case for mixed joint and separate TCIs is that one of the 2 TRPs suffers MPE can use the separate TCIs, as elaborated in last round. Prefer not to restrict configuration flexibility.   * One of the following combinations can be applied in a CC/BWP for MTRP operation:   + […]   + 1 pair of DL and UL TCI states + 1 UL TCI state   + 1 pair of DL TCI states   + FFS: 3 joint TCI states   + […]   [Mod] Added with brackets. More clarification on this combination may be needed, i.e., what the difference from the combination of 2 joint TCI states?  For 1.3, as elaborated in last round, the use case for mixed joint and separate TCIs is that one of the 2 TRPs suffers MPE can use the separate TCIs. Prefer not to restrict configuration flexibility.  For 1.4, Support Alt1 to simplify the configuration. It also provides gNB flexibility to allocate different # of TCIs among the two TRPs. Total configured TCI # can be discussed separately |
| OPPO | For **Proposal 1.A**: as we stated in the pre-meeting discussion, we still couldn’t find clear hint for the necessity of enhancing unified TCI for CJT in the Rel.18 MIMO WID. But if that’s the majority’s view to have it discussed again, we are okay to re-open the box focusing on two indicated joint/DL TCI states for CJT.  Slight modification can be found below. Since in the main bullet, it says “QCLed with the DL RSs of the two joint/DL TCI states”, we suggest to change “more than one” into “two” to be more aligned and clear.  **Proposal 1.A**: On unified TCI framework extension, ~~more than one~~ two joint/DL TCI states can be applied simultaneously to CJT-based PDSCH reception, i.e., the UE shall assume that the PDSCH DM-RS port(s) is QCLed with the DL RSs of the two joint/DL TCI states   * FFS: The maximum number of joint/DL TCI states that can be applied simultaneously for CJT-based PDSCH reception(s)   For **Proposal 1.B**: support in principle. Regarding the first two FFS for CJT, i.e. 3 or 4 joint TCI states, we think joint TCI states should be replaced by DL TCI states. Consider the fact that CJT operates only in DL at FR1 in which UL spatial relation was not specified in Spec.   * + FFS: 3 ~~joint~~ DL TCI states   + FFS: 4 ~~joint~~ DL TCI states   [Mod] Done  There might be one more issue to be clarified related the following sub-bullet. That is when either 1 DL or UL TCI state is indicated/updated for one TRP, should UE maintain the unchanged UL or DL TCI state for the TRP or only apply the indicated DL or UL TCI state for the TRP?   * + 1 pair of DL and UL TCI states + 1 DL TCI state   + 1 pair of DL and UL TCI states + 1 UL TCI state   + FFS: 1 joint TCI state + 1 DL TCI state   + FFS: 1 joint TCI state + 1 UL TCI state   [Mod] We will need to clarify this issue for sure. |
| Google | On **Proposal 1.A**: We agree with QC’s revision. Since, as mentioned in sub-bullet, the maximum number of joint/DL TCI states that can be applied simultaneously is still FFS, we should change “two” to “more than one”.  On **Proposal 1.B**: As we mentioned in offline, we don’t think per-TRP configuration of joint/separate TCI mode is useful. Even only one TRP is facing MPE issue, it would also impact selection of the beam(s) that can be used to communicate with the other TRP. In addition, supporting this would make the whole discussion quite complicated, where many combinations need to be discussed and justified even without considering CJT. |
| Mod V04 | **Proposal 1.A and Proposal 1.B are revised according to above feedback** |
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# Issue 2 – TCI state update and activation

Table 2-1 Summary for Issue 2

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| **#** | **Issue** | **Companies’ views** | **FL note/observation** |
| 2.1 | TCI state update for M-DCI based MTRP  Alt1: Reuse the same TCI state update scheme for S-DCI based MTRP  Atl2: Use the existing TCI field in the DCI format 1\_1/1\_2 (with or without DL assignment) associated with one of *coresetPoolIndex* values to indicate the joint/DL/UL TCI state(s) corresponding to the same *coresetPoolIndex* value  Alt3: Use the existing TCI field in any DCI format 1\_1/1\_2 (with or without DL assignment) to indicate all joint/DL/UL TCI states corresponding to both *coresetPoolIndex* values  Alt4: Use the existing TCI field in the DCI format 1\_1/1\_2 (with or without DL assignment) associated with one of *coresetPoolIndex* values to indicate joint/DL/UL TCI state(s) corresponding to the same or different *coresetPoolIndex* value | Alt1: Ericsson, Sharp  Alt2: Apple, Nokia, CATT, CEWiT, CMCC, Docomo, MediaTek, FGI, Fraunhofer, Fujitsu, Futurewei, Huawei/HiSilicon, Intel, LG, OPPO, Panasonic, Qualcomm, Samsung. Sharp, vivo  Alt3: FGI, TransHold  Alt4: ZTE, FGI, Fraunhofer, Spreadtrum, TransHold, Xiaomi, Google | Given the majority view, Proposal 2.A is recommended for this issue  How to activate TCI states for M-DCI based MTRP can be discussed later |
| 2.2 | For S-DCI based MTRP, introduce/re-interpret DCI field(s) other than the existing TCI field for TCI state update | Support: FGI, Google, Huawei/HiSilicon, Samsung  Concern: Intel, QC, OPPO |  |
| 2.3 | For S-DCI based MTRP, increase the max number of TCI field bits (i.e., support more (>8) combinations of activated TCI states mapped to the TCI codepoints) | Support: Apple, Nokia, Docomo, FGI (if not support additional field for TCI state update), ITRI, Panasonic, Samsung  Concern: Futurewei, Lenovo, OPPO (not for joint DL/UL TCI update), vivo, QC |  |

**Proposal 2.A:** On unified TCI framework extension for M-DCI based MTRP, use the existing TCI field in a DCI format 1\_1/1\_2 (with or without DL assignment) associated with one of *coresetPoolIndex* values to indicate at least the joint/DL/UL TCI state(s) associated with the same *coresetPoolIndex* value

* FFS: Whether and how to indicate the joint/DL/UL TCI state(s) associated with another *coresetPoolIndex* value

Table 2-2 Additional inputs for Issue 2

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| **Company** | **Input** |
| Mod V00 | **Please update your view on those sub-issues in Table 2-1 and check above moderator proposal** |
| QC | For 2.1, support Alt2. To our understanding, sDCI focuses on joint scheduling, while mDCI is mainly for separate scheduling, where the TRP ID (CORESETPoolIndex) simplifies the design a lot for mDCI. So we believe following the legacy per-CORESETPoolIndex TCI indication is most efficient for mDCI. For Alt3 & 4, the use case for cross-TRP TCI indication seems not strong for mDCI and may also increase DCI overhead to affect reliability.  For Proposal 2.A, ok for current form. Btw, “Proposal 1.B” in row 2.1 seems should be “Proposal 2.A”  For 2.2 and 2.3, we think current TCI field with 8 codepoints are sufficient for sDCI |
| OPPO | For **Proposal 2.A**: Support.  Recall the difference between S-DCI and M-DCI MTRP operations in legacy release (w.o. CORESETPoolIndex or w. CORESETPoolIndex) and implementations (ideal backhaul with joint scheduling or non-ideal backhaul with independent scheduling), we may not need to pursue unified solution for UTCI state indication/update. Finding the most applicable UTCI indication/update scheme(s) for each MTRP operation can be a good choice.  For **Issue 2.2**, whether to introduce/re-interpret DCI field(s) for UTCI indication/updating can be related to other aspects, such as MAC CE for activating UTCI states for MTRP. Without clear justification on its purpose and necessity, we by now are hesitate to change the existing DCI format which could increase UE’s decoding complexity. |
| Google | On **Proposal 2.A**: We disagree with this proposal. Actually, cross-TRP beam indication has been supported in Rel-16 M-DCI. We wonder why Rel-18 unified TCI extension would be less flexible than Rel-16 beam indication.  On **Issue 2.2** and **2.3**: They are a bit related. Our first preference is to add an additional TCI field. However, increasing more bits for existing TCI field is OK to us if it is majority view. |
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# Issue 3 – How to associate the indicated TCI state(s) with each target channel/signal

Table 3-1 Summary for Issue 3

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| **#** | **Issue** | **Companies’ views** | **FL note/observation** |
| 3.1 | Down-selection from the following alternatives for the association between joint/DL TCI state(s) and PDCCH reception in S-DCI based MTRP  Atl1: Use RRC configuration to inform the mapping/association between a configured or indicated joint/DL TCI state and a CORESET or a CORESET group  Alt2: Use RRC configuration to inform the mapping/association between a configured or indicated joint/DL TCI state and a search space set  Alt3: Use MAC-CE to inform the mapping/association between an activated or indicated joint/DL TCI state and a CORESET or a CORESET group  Alt4: Use DCI to inform the mapping/association between an indicated joint/DL TCI state and a CORESET or a CORESET group  Alt5: Based on a fixed mapping/association rule, e.g., the first indicated joint/DL TCI state always applies to PDCCH receptions | Alt1: Apple, Nokia (PDCCH repetition), CATT, ZTE (CORESET group), MediaTek, Docomo, Fraunhofer (for non-SFN), Fujitsu (STRP), Futurewei, Lenovo, LG, NEC, OPPO, Qualcomm, Samsung (CORESET group), vivo (CORESET group), Xiaomi (PDCCH w/o repetition/SFN)  Alt2: Apple, Ericsson  Alt3: Google, Huawei/HiSilicon (switching between SFN and non-SFN), Xiaomi  Alt4:  Alt5: Nokia (STRP and PDCCH-SFN), CEWiT, Huawei (PDCCH repetition), Fujitsu (STRP), Futurewei, Intel, ITRI, Lenovo, OPPO, Panasonic, Samsung (PDCCH repetition) | Given the majority view, Proposal 3.A with the down-selection is recommended for this issue |
| 3.2 | DG-PDSCH and SPS-PDSCH in S-DCI based MTRP, inform the UE at least the following:   * Apply one (i.e., STRP) or multiple (i.e., MTRP) indicated joint/DL TCI states to the PDSCH reception(s) | Alt1-Use an indicator field other than the existing TCI field (could be an existing DCI field or a new DCI field) in the scheduling DCI: Apple, Nokia, CATT, ZTE, CMCC, Docomo, MediaTek, Huawei/HiSilicon, Lenovo, Qualcomm, Sharp, vivo  Alt1-1-Reuse existing TCI field (number of indicated joint/DL TCI state(s)) in the scheduling DCI: OPPO  Alt2-Use an RRC-based association: Ericsson | Proposal 3.B is provided for this issue |
| 3.3 | DG-PUSCH and Type-2 CG-PUSCH in S-DCI based MTRP, inform the UE the followings:   * Apply one (i.e., STRP) or two (i.e., MTRP) indicated joint/UL TCI states, and the ordering to the PUSCH transmission(s) * If apply only one, which indicated joint/UL TCI state to the PUSCH transmission(s) | Alt1-Use an indicator field (could be an existing DCI field or a new DCI field) in the scheduling DCI: Apple, Nokia (non-fallback DCI), CATT, CMCC, Docomo, MediaTek, Intel (for indicating a TCI codepoint different from that for DL), Lenovo, OPPO, Sharp, vivo, Xiaomi, QC  Alt2-Follow the joint/UL TCI state(s) applying to the SRS resource(s) indicated by SRI(s): Huawei/HiSilicon, Ericsson  Alt3-Use an RRC-based association: Nokia (Type-1 CG) | Proposal 3.C is provided for PUSCH transmission scheduled/activated by a DCI 0\_1/0\_2 (including DG-PUSCH and Type-2 CG-PUSCH)  The association scheme for Type-1 CG-PUSCH and PUSCH activated/scheduled by DCI 0\_0 can be further studied |
| 3.4 | Dedicated PUCCH resource or PUCCH resource group in S-DCI based MTRP, inform the UE the followings:   * Apply one (i.e., STRP) or two (i.e., MTRP) indicated joint/UL TCI states to the PUCCH transmission(s) * If apply only one, which indicated joint/UL TCI state to the PUCCH transmission(s) | Alt1-Use an RRC-based association: Apple, Ericsson, MediaTek, Lenovo, Xiaomi, QC, OPPO  Alt2-Use a MAC CE-based association: CATT, Huawei/HiSilicon (switching between repetition and non-repetition), Xiaomi  Alt3-Use a DCI-based association: Docomo (for PUCCH triggered by DCI 1\_1/1\_2), Intel (introduce an TCI field in DCI 0\_1/0\_2 to indicate a TCI codepoint different from that for DL) | Proposal 3.D is provided for this issue |
| 3.5 | PDCCH in M-DCI based MTRP (neither PDCCH repetition nor PDCCH-SFN is enabled) | Alt1-For PDCCH on a CORESET associated with a *coresetPoolIndex* value, follow the indicated TCI state corresponding to the *coresetPoolIndex* value: Apple, Nokia, Futurewei, Lenovo, vivo, MediaTek, QC, OPPO  Alt2-Reuse the same association scheme for S-DCI based MTRP: Ericsson | A proposal for this issue will be provided in a later version with sufficient input from companies  Whether PDCCH repetition/SFN can be supported together in M-DCI based MTRP can be further discussed |

**Proposal 3.A:** On unified TCI framework extension, to inform the association with the joint/DL TCI state(s) indicated by DCI/MAC-CE for PDCCH repetition, PDCCH-SFN, and PDCCH w/o repetition/SFN, down-selection at least one alternative from the followings:

* Atl1-1: Introduce RRC parameter(s) in a CORESET configuration to inform whether/which indicated joint/DL TCI state(s) the UE shall apply to the corresponding PDCCH receptions on the CORESET
  + FFS: Whether only the CORESET(s) that always/can share the unified TCI state as defined in Rel-17 unified TCI framework can be associated with the joint/DL TCI state(s) indicated by DCI/MAC-CE
* Alt1-2: Introduce an RRC parameter in a CORESET configuration to inform that the CORESET belongs to which CORESET group(s), and the indicated joint/DL TCI state is 1-to-1 associated with each CORESET group
  + FFS: Whether only the CORESET(s) that always/can share the unified TCI state as defined in Rel-17 unified TCI framework can be associated with the CORESET group(s)
* Alt2: The association between a CORESET and the indicated joint/DL TCI state(s) is determined based on a fixed rule
  + FFS: Whether only the CORESET(s) that always/can share the unified TCI state as defined in Rel-17 unified TCI framework can be associated with the joint/DL TCI state(s) indicated by DCI/MAC-CE

**Proposal 3.B:** On unified TCI framework extension for S-DCI based MTRP, to inform the association with joint/DL TCI state(s) indicated by DCI/MAC-CE and enable dynamic switching between STRP and MTRP operations for PDSCH reception, down-selection one alternative from the followings:

* Atl1: Introduce an indicator field other than the existing TCI field (could be an existing DCI field or a new DCI field) in a DCI format 1\_1/1\_2 to inform which indicated joint/DL TCI state(s) the UE shall apply to PDSCH reception scheduled/activated by the DCI format 1\_1/1\_2
  + FFS: PDSCH reception scheduled/activated by DCI format 1\_0
* Alt2: Introduce RRC parameter(s) in a PDSCH configuration in a DL BWP to inform which indicated joint/DL TCI state(s) the UE shall apply to PDSCH reception in the DL BWP
  + Note: Dynamic switching between STRP and MTRP operations can be achieved by indication of all the same or different joint/DL TCI states

**Proposal 3.C:** On unified TCI framework extension for S-DCI based MTRP, to inform the association with joint/UL TCI state(s) and enable dynamic switching between STRP and MTRP operations for PUSCH transmission scheduled/activated by a DCI format 0\_1/0\_2, down-selection one alternative from the followings:

* Atl1: Introduce an indicator field (could be an existing DCI field or a new DCI field) in a DCI format 0\_1/0\_2 to inform which joint/UL TCI state(s) indicated by MAC-CE/DCI the UE shall apply to PUSCH transmission scheduled/activated by the DCI format 0\_1/0\_2
* Alt2: PUSCH transmission scheduled/activated by a DCI format 0\_1/0\_2 follows the joint/UL TCI state(s) applying to the SRS resource(s) indicated by the DCI format 0\_1/0\_2

FFS: PUSCH transmission scheduled/activated by a DCI format 0\_0 and Type-1 CG-PUSCH

**Proposal 3.D:** On unified TCI framework extension for S-DCI based MTRP, to inform the association with joint/UL TCI state(s) indicated by DCI/MAC-CE for PUCCH transmission, down-selection at least one alternative from the followings:

* Atl1: Use RRC configuration to inform the association between the indicated joint/UL TCI state(s) and a PUCCH resource/ group
* Atl2: Use MAC-CE to inform the association between the indicated joint/UL TCI state(s) and a PUCCH resource/group
* Atl3: Use DCI to inform the association between the indicated joint/UL TCI state(s) and a PUCCH resource/group

Table 3-2 Additional inputs for Issue 3

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| **Company** | **Input** |
| Mod V00 | **Please update your view on those sub-issues in Table 3-1 and check above moderator proposals** |
| QC | For Proposal 3.A, ok for current form. For dynamic association via MAC-CE/DCI, we think RRC to change association for CORESET is sufficient. This is similar to RRC configured CORESETPoolIndex. Dynamic association will also impact overhead.  For Proposal 3.B, some clarification for Alt2 would be good. Does it mean DCI indicating same TCIs will imply sTRP operation? If so, gNB may need to send another DCI later to resume the mTRP operation.  For Proposal 3.C, suggest the following wording. To our understanding, reusing existing SRS resource set indicator is sufficient.   * Atl1: ~~Introduce~~ Use an indicator field (could be an existing DCI field or a new DCI field) in a DCI format 0\_1/0\_2 to inform which joint/UL TCI state(s) indicated by MAC-CE/DCI the UE shall apply to PUSCH transmission scheduled/activated by the DCI format 0\_1/0\_2   For Proposal 3.D, ok for the current form. Support Alt1. The use case for dynamic update the association seems not strong.  For 3.5, support Alt1, which is more efficient for mDCI due to the use of CORESETPoolIndex |
| OPPO | For **Proposal 3.A**: Support.  For **Proposal 3.B**: In our view, the PDSCH dynamic switch between STRP and MTRP should be supported with unified TCI state(s). Without changing the DL DCI format, UE can identify STRP/MTRP PDSCH reception by the number of indicated joint/DL TCI state(s) in DCI, though not applicable yet. Afterwards, UE applies the applicable joint/DL TCI state(s) for corresponding PDSCH reception (either STRP or MTRP). Specifically, 1 indicated joint/DL TCI state in DCI implies STRP PDSCH and 2 indicated joint/DL TCI states in DCI implies MTRP PDSCH.  Along with the two listed alternatives, can we suggest another Alt1-1 for the group to consider? Thanks.  **Proposal 3.B:** On unified TCI framework extension for S-DCI based MTRP, to inform the association with joint/DL TCI state(s) indicated by DCI/MAC-CE and enable dynamic switching between STRP and MTRP operations for PDSCH reception, down-selection one alternative from the followings:   * Atl1: Introduce an indicator field other than the existing TCI field (could be an existing DCI field or a new DCI field) in a DCI format 1\_1/1\_2 to inform which indicated joint/DL TCI state(s) the UE shall apply to PDSCH reception scheduled/activated by the DCI format 1\_1/1\_2   + FFS: PDSCH reception scheduled/activated by DCI format 1\_0 * Alt1-1: Reuse the existing TCI field in DCI format 1\_1/1\_2, i.e. the number of indicated joint/DL TCI state(s) to imply either STRP or MTRP PDSCH reception * Alt2: Introduce RRC parameter(s) in a PDSCH configuration in a DL BWP to inform which indicated joint/DL TCI state(s) the UE shall apply to PDSCH reception in the DL BWP   + Note: Dynamic switching between STRP and MTRP operations can be achieved by indication of all the same or different joint/DL TCI states   For **Proposal 3.C**: Support in principle.  In our reading, Alt.3 (RRC-based association) may not conflict with Alt.1 (introduced indicator field in UL DCI). For instance, the association between SRS resource set(s) (for STRP/MTRP in Rel.17 MTRP PUSCH) and joint/UL TCI state(s) via RRC configuration can be the basis for Alt.1 (using an existing DCI field, i.e. SRS resource set). Perhaps Alt.3 can be clarified or merged with Alt.1.  For **Proposal 3.D**: Support.  For **Issue 3.5**, it seems overlapped with issue 2.1 and we add our preference in Table 3-1. |
| Google | On **Proposal 3.A**: Not support. Please note that from Rel-15, beam indication for PDCCH has been done by MAC-CE activation for a CORESET. Why we want to back to RRC configuration indication? Another one issue is in Rel-17, PDCCH-SFN and PDCCH w/o SFN can be dynamically switched by MAC-CE. How this can be achieved if we adopt RRC configuration to indicate beam?  On **Proposal 3.B**: Support. And Alt1 is our preference.  On **Proposal 3.C**: Support. We prefer Alt1, which is quite similar to existing behavior introduced in Rel-17 MTRP PUSCH.  On **Proposal 3.D**: Support. And we should go with Alt2 since PUCCH resource has been indicated beam by MAC-CE from the very beginning.  On **Issue 3.5**: it seems related to Issue 2.1. We should consider them together. |

# Issue 4 – UL power Control for UL MTRP

Open issues on UL power control for UL MTRP are summarized below.

Table 4-1 Summary for Issue 4

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| **#** | **Issue** | **Companies’ views** | **FL note/observation** |
| 4.1 | How to determine the UL PC parameter setting(s) if one or both indicated joint/UL TCI state(s) is not associated with an UL PC parameter setting (including P0, alpha for PUSCH, and closed loop index) for PUCCH/PUSCH | Alt1-Follow the UL PC parameter setting(s) provided in the corresponding UL BWP, i.e., support two default UL PC parameter settings configured in *BWP*-*UplinkDedicated*: Huawei, Qualcomm, MediaTek, TransHold, Xiaomi, OPPO  Alt2-Follow the one single UL PC parameter setting provided in in *BWP*-*UplinkDedicated* regardless the UL PC parameter setting is absent from one or both of indicated joint/UL TCI states: Ericsson  Alt3-Follow the UL PC parameter setting with the lowest index: Apple | A proposal for this issue will be provided in a later version with sufficient input from companies |
| 4.2 | Enhance Type-1 PHR for MTRP with TCI-specific UL PC parameter setting | Support: Qualcomm  Concern: |  |

**Proposal 4.A:** On unified TCI framework extension, if one or both of indicated joint or UL TCI states applying to PUSCH/PUCCH transmission occasions at least for S-DCI based PUSCH/PUCCH repetition with TDM is not associated with an UL PC parameter setting (including P0, alpha for PUSCH, and closed loop index) for PUCCH/PUSCH, down-selection one alternative from the followings:

*Waiting for more input*

Table 4-2 Additional inputs for Issue 4

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V00 | * **Please update your view on those sub-issues in Table 4-1** * **Share additional inputs here, especially for open issue that needs to be addressed with higher priority but is not captured in Table 4-1** |
| QC | For Proposal 4.A, we think Alt1 will provide same flexibility as legacy R17, which already supports two UL PC parameter sets.  For 4.2, we think the same principle agreed for sTRP is also beneficial for mTRP |
| OPPO | For **Proposal 4.A**: For MTRP PUCCH/PUSCH, it seems more reasonable to apply the two default UL PC parameter settings (specified in Rel.17 MTRP PUCCH/PUSCH), otherwise as implied by Alt2, UE has to fallback to UL PC for STRP. Our preference added in Table 4-1.  Moreover, since STxMP (if supported) can be considered with extension of UTCI in Rel.18, we think STxMP (not only PUCCH/PUSCH repetition with TDM) should be considered in Proposal 4.A as well. |
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# Issue 5 – Beam reporting and beam failure recovery

Open issues on beam reporting and BFR enhancements and company views are summarized below.

Table 5-1 Summary for Issue 5-1

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| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 3.1 | Enhance/extend group-based reporting to support simultaneous UL transmission | Support: QC  Concern: OPPO | This issue can be discussed once any Rel-18 MTRP scheme for STxMP is agreed |
| 3.2 | Enhance/extend Rel-17 UE capability index reporting to support simultaneous UL transmission | Support: QC, OPPO  Concern: | This issue can be discussed once any Rel-18 MTRP scheme for STxMP is agreed |
| 3.3 | Enhancement to TRP-specific BFR under unified TCI framework | Support: QC, OPPO  Concern: |  |

Table 5-2 Additional inputs for Issue 5

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| --- | --- |
| **Company** | **Input** |
| Mod V00 | * **Please update your view on those sub-issues in Table 5-1** * **Although Issue 5 will be treated with lower priority in this meeting, companies still can share additional inputs here** |
| QC | Support 3.1 and 3.2, but fine to wait till STxMP decision is clear  Support 3.3. We think the same principle agreed for sTRP is also beneficial for mTRP |
| OPPO | For Issue 3.1, we understand the group-based beam reporting was for DL MTRP operation, while the STxMP is for UL only. It seems unnecessary to combine these two features.  Support Issue 3.2 and 3.3. It seems reasonable to discuss Issue 3.2 when STxMP is agreeable. |
|  |  |

# Other potential issues

Table 6 Inputs for other potential issues

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| --- | --- |
| **Company** | **Input** |
| Mod V00 | **Please share your view if there is any open issue that need to be addressed with higher priority but is not captured in above sections** |
|  |  |

# Appendix A: Agreements before/in RAN1#110

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| --- |
| **RAN1#109e** |
| **Agreement**  On unified TCI framework extension, consider all the intra and inter-cell MTRP schemes specified in Rel-16 and Rel-17   * Consider, if STxMP is supported, Rel-18 MTRP scheme(s) with STxMP   **Agreement**  On unified TCI framework extension at least for single-DCI based MTRP, the existing TCI field in DCI format 1\_1/1\_2 (with or without DL assignment) can indicate multiple joint/DL/UL TCI states in a CC/BWP or a set of CCs/BWPs in a CC list   * FFS: Detail of mapping joint/DL/UL TCI state ID(s) to a TCI codepoint, e.g., possible combinations of joint, DL, and/or UL TCI state IDs that can be mapped to a TCI codepoint * FFS: Whether to increase the max number of MAC CE activated TCI codepoints, i.e., more than 8 codepoints * FFS: Whether to increase the max number of TCI field bits, i.e., more than 3 bits * Note: This doesn't imply that support of one additional TCI field or a field associating the TCI field to the TRP(s) is precluded   Note: The term TRP is used only for the purposes of discussions in RAN1 and whether/how to capture this is FFS  **Agreement**  On unified TCI framework extension for M-DCI based MTRP, consider the following alternatives for TCI state update:   * Alt1: Reuse the same TCI state update scheme for S-DCI based MTRP * Atl2: Use the existing TCI field in the DCI format 1\_1/1\_2 (with or without DL assignment) associated with one of *CORESETPoolIndex* values to indicate the joint/DL/UL TCI state(s) corresponding to the same *CORESETPoolIndex* value * Alt3: Use the existing TCI field in any DCI format 1\_1/1\_2 (with or without DL assignment) to indicate all joint/DL/UL TCI states corresponding to both *CORESETPoolIndex* values   + Study the association between the indicated joint/DL/UL TCI state(s) and a *CORESETPoolIndex* value * Alt4: Use the existing TCI field in the DCI format 1\_1/1\_2 (with or without DL assignment) associated with one of *CORESETPoolIndex* values to indicate joint/DL/UL TCI state(s) corresponding to the same or different *CORESETPoolIndex* value.   + Study whether the indicated joint/DL/UL TCI state(s) applies to the channels/signals associated with the same *CORESETPoolIndex* value or different *CORESETPoolIndex* value is indicated by DCI   **Agreement**  On unified TCI framework extension for S-DCI based MTRP, consider at least the following alternatives to map/associate a joint/DL TCI state to PDCCH reception(s)   * Atl1: Use RRC configuration to inform the mapping/association between a configured or indicated joint/DL TCI state and a CORESET or a CORESET group * Alt2: Use RRC configuration to inform the mapping/association between a configured or indicated joint/DL TCI state and a search space set * Alt3: Use MAC-CE to inform the mapping/association between an activated or indicated joint/DL TCI state and a CORESET or a CORESET group * Alt4: Use DCI to inform the mapping/association between an indicated joint/DL TCI state and a CORESET or a CORESET group * Alt5: Based on a fixed mapping/association rule, e.g., the first indicated joint/DL TCI state always applies to PDCCH receptions   Consider above alternatives for PDCCH repetition, PDCCH-SFN, PDCCH w/o repetition/SFN, and potential support of dynamic switching between S-TRP and M-TRP for PDCCH. It is not precluded to adopt one single alternative or multiple alternatives to support these cases.  **Agreement**  On unified TCI framework extension, if an indicated joint or UL TCI state applies to a PUSCH/PUCCH transmission occasion at least for S-DCI based PUSCH/PUCCH repetition with TDM and the indicated joint or UL TCI state is associated with an UL PC parameter setting for PUSCH /PUCCH (including P0, alpha for PUSCH, and closed loop index) and a PL-RS, the UE should apply the UL PC parameter setting and the PL-RS for the PUSCH /PUCCH transmission occasion.   * FFS: How to extend to other Rel-18 MTRP scheme(s) with STxMP, if supported * FFS: UL PC enhancement for CB and non-CB SRS in above case   FFS: The applied UL PC parameter setting if one or both indicated joint or UL TCI state(s) is not associated with an UL PC parameter setting (including P0, alpha for PUSCH, and closed loop index) for PUCCH/PUSCH  **Agreement**  On UE power limitation for STxMP for FR2, send LS to RAN4 to check the followings:   * Whether it is feasible to assume power limitation per panel for STxMP (Assumption 1) * Whether it is feasible to assume a total power limitation per UE over all UE panels used for STxMP (Assumption 2) * In either of Assumption1 or Assumption 2, whether the total power limitation per UE over all UE panels used for STxMP or the sum of per-panel power limitation for STxMP can be different from (greater than) the existing power limitation for a given power class? * If both Assumption 1 and Assumption 2 are feasible, whether both assumptions can be applied to a same UE, and what is the relationship between the per-panel power limitation and total power limitation if both are applied (e.g., the sum of per-panel power limitation can be larger than the total power limitation per UE, or should be always the same)?   FFS: Detail of exact LS if agreed  Note: Scenarios of above include at least single carrier scenario for FR2  Note: Above power limitation includes both total radiated power and EIRP  LS to RAN4 is endorsed in R1-2205639. |
| **RAN1#110** |
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# Appendix B: Pre-meeting offline discussion on Issue 1

Table 1-1 Summary for Issue 1

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| **#** | **Issue** | **Companies’ views** | **FL note/observation** |
| 1.1 | Whether to support applying multiple joint/DL TCI states simultaneously to CJT-based PDSCH reception(s) | Support: Google, Ericsson, Docomo, ZTE(in principle), Lenovo, Intel(in principle), FGI, Huawei/HiSilicon  Concern: vivo, NEC, Fujitsu, IDC, Apple, Spreadtrum, QC (ok for SFN)  Out-of-scope: OPPO | This is not supported in current spec, so it must be discussed and decided first before further considering CJT in unified TCI extension. On the other hand, this issue may be out of the Rel-18 MIMO scope. |
| 1.2 | For the target use cases agreed in RAN1#109e, up to 2 sets of TCI states (TCI set) can be indicated and applied in a CC/BWP   * Each TCI set comprises one joint TCI state for joint DL/UL TCI update, or one DL TCI state and/or one UL TCI state for separate DL/UL TCI update * The joint/DL/UL TCI state(s) within each TCI set is indicated/updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation | Support: Docomo, vivo, ZTE, OPPO, NEC, Fujitsu, Lenovo, LG Xiaomi, Spreadtrum, QC  Concern: Google, Ericsson, IDC (premature and no need to use “sets”), Huawei/HiSilicon (OK with 2nd sub-bullet) | We can focus on the target use cases agreed in RAN1#109e first, and the max number for CJT (up to 4 TRPs can be supported for Rel-18 CJT) can be further discussed if there is any agreement on Issue 1.1. Note that whether to prioritize or only support NTRP = {1,2} over {3,4} is also an on-going discussion in AI 9.1.2. |
| 1.3 | How to configure/determine the exact number of TCI states that UE needs to apply in a CC/BWP? | Based on a unified configuration/determination scheme (e.g., RRC configuration, TCI state activation, or the indicated TCI codepoint):  Based on the configuration/enabling of MTRP scheme(s) in the CC/BWP:  Others: | Note that indicated/applied TCI states in a CC/BWP may be shared by multiple DL/UL channels with different STRP/MTRP schemes  Conclusion on Issue 1.3 may impact the later design(s) on mapping/ association between the indicated TCI state(s) and target channel(s)/signal(s) |
| 1.4 | Whether joint DL/UL TCI update and separate DL/UL TCI update can be supported in a same CC/BWP simultaneously?  For the use case e.g., one TRP with joint DL/UL TCI update and another with separate DL/UL TCI update. | Support: Intel, FGI, Huawei/HiSilicon, QC  Concern: Google, OPPO, Lenovo, LG, Spreadtrum |  |

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| --- | --- |
| **Company** | **Input** |
| Google | Issue 1.1: Given the introduction of CJT in R18, it seems hard to overlook the fact of 4 TRPs.  Issue 1.2: We are afraid it is too risky to say up to 2 TCI sets can be indicated/applied in a BWP/CC. At least for FR2, we should support up to 4 TCI sets considering CJT.  Issue 1.4: In our views, there are few cases that UE communicates with one TRP using separate TCI, and on the other hand, communicates with the other one using joint TCI. |
| Ericsson | Issue 1.1: It would seem unfortunate to exclude CJT, since the specification impact would be very small, considering that we already agreed to support 2 DL + 2 UL TCI states.  Issue 1.2: The definition of a “TCI set” is not motivated.  Issue 1.3: Unclear. Why should we determine the exact number of TCI states? The UE needs to determine which TCI states to apply, and the number of TCI states will follow automatically. In our understanding, the UE should be able to apply one, two, three of four TCI states, based on a combination of RRC configuration, MAC CE activation, and DCI indication.  Issue 1.4: This can be discussed later. |
| Docomo | Issue 1.1: We believe unified TCI should support CJT. If CJT is supported by only Rel.15/16 TCI state/spatial relation, we have concern, because it means gNB needs to select either CJT or other Rel.17/18 features using unified TCI state per a band. This was the reason why we need to extend unified TCI framework for M-TRP in Rel.18.  Issue 1.2: We think the intention is to focus on M-TRP operation and keep open for CJT. We are fine, but we should clarify as “up to 2 sets of indicated TCI states (indicated TCI set)”.  By the way, if this proposal is controversial, perhaps we can skip this issue for now. For example, we can discuss using terminology of “M indicated TCI states (FFS: the value of M)”.  Issue 1.3: Question is not clear to us. In our understanding, UE can understand the number of indicated TCI states based on DCI/MAC CE/RRC beam indication. However, even if two TCI states are indicated, two TCI states cannot be applied to some CH/RS (e.g. S-TRP PDSCH/PUSCH/PUCCH/PUSCH, non-SFN CORESET, CSI-RS, SRS). In that case, UE should select one TCI state from the two indicated TCI states.  Issue 1.4: We are not opposing to specify such operation, but its discussion priority in AI9.1.1.1 is not high. |
| Vivo | Issue 1.1: A better way to go is to first focus on MTRP schemes specified in Rel-16 and Rel-17, and potential Rel-18 MTRP scheme(s) with STxMP to avoid new CJT schemes making the discussion complicated. We are fine to have a parallel discussion specific to CJT, but CJT should try to follow the eUTCI framework for MTRP without impacting eUTCI framework for Rel-16/17 MTRP.  Issue 1.2: Agree with FL’s observation on CJT.  Issue 1.3: Unclear issue to us. In our mind, it should be a channel-specific determination for MTRP scheme as Rel-16 and Rel-17. When a UE is indicated with two UTCI states for DL or UL, whether each individual channel apply one or two UTCI states is separately determined.  Issue 1.4: We are open to this issue. But a mixed UTCI type for different TRPs would make the UTCI activation and indication a little bit complicated but provide flexibility. |
| ZTE | Issue 1.1: For CJT, a single TCI state should be assumed as a starting point, and then we are open to further consider more-than-one-TCI state indication if a clear usage/benefit can be justified. Even having more than one TCI state, we think that the QCL-Type should be justified. QCL-TypeA + QCL-TypeA or we need to consider a principle TCI state and secondary TCI state(s) for some parts of QCL assumption, as what we did for SFN, quite like what we need to handle in the CJT.  Issue 1.2: A good starting point for facilitating the subsequent discussion for the separate indication like ‘DL TCI + UL TCI’ for one TRP and ‘DL TCI + UL TCI’ for another TRP. For CJT, we may discuss the corresponding UE behavior later. Although from TCI indication perspective CJT is quite like mTRP, if we concentrate on a DL/UL transmission, CJT is almost the same as sTRP operation. We may need to handle this case carefully, e.g.,, CJT + CJT.  Issue 1.3: Technical speaking it is a good question, and anyway we need to make a clear decision for a given UE transmission. But, it may be relevant to roadmap/way-forward for making progress on this topic. We slightly prefer to use the typical roadmap: case-by-case discussion for TCI activation/indication and the subsequent association for each DL or UL channel/RS. If above is clear, this issue can be well handled with transparent manner.  Issue 1.4: The motivation is unclear for us. Could any proponents nicely clarify why/how two TRPs need to be treated differently in terms of joint and separate indication? |
| OPPO | Issue 1.1: In the WID of Rel.18 MIMO enhancement (RP-213598), it says “Study, and if justified, specify enhancements of CSI acquisition for Coherent-JT targeting FR1 and up to 4 TRPs”. Clearly, the specification effort should focus on CSI. We failed to see any hint in the WID that UE has to boost its capability for up to 4 DL TCI states simultaneously.  With ideal backhaul and synchronization, this CJT enhancement targets on FR1 (e.g. 700MHz) in which UE can apply very wide Rx beam(s) for DL receptions from different directions. Therefore, 1 or 2 legacy (Rel.15/16) TCI state(s) specified for MTRP PDSCH in Rel.16 would also work well. In our view, it seems out of scope and unnecessary to be enhanced.  Issue 1.2: the concept of indicated TCI set seems a good starting point for unifying the beams in a TRP-specific manner. The terminology “TCI set” may cause inconvenience among the group, but we think at least “TCI set” can be used for discussion purpose and how to capture it is up to editor.  Issue 1.3: it is highly likely that the TCI state(s) indication for MTRP follow the conventional way, i.e. RRC + MAC CE + DCI as in Rel.17 for STRP. Regarding on how determine the exact number of indicated TCI state(s), we tend to believe it should be done on a per channel basis, depending on the transmission scheme of each channel. For instance, if 2 DL/joint TCI states are indicated, only 1 of the 2 indicated TCI states will apply to STRP PDSCH, whereas 2 indicated ones will apply to MTRP PDSCH.  Issue 1.4: we also failed to see strong motivation on mixed mode of TCI states, i.e. configuring joint TCI states for one TRP and separate DL/UL TCI states for the other TRP. It seems no additional complexity for following the configuration rule in Rel.17 for STRP. |
| NEC | Issue 1.1: According to WID, it is out of scope. Also, we don’t think CJT operation requires fast TCI update schemes like what is/will be specified in Rel-17/18. In addition, the unified TCI state is motivated by the need of “common beam”, but we don’t think in CJT we will support the common beam of PDCCH/PDSCH.  Issue 1.2: Support.  Issue 1.3: Generally speaking, the exact number of applied TCI states should be determined based on TCI state activation/indication signaling. But we are also not sure about the exact intension of this question.  Issue 1.4: We are open to it. |
| Fujitsu | Issue 1.1: In the WID, unified TCI is explicitly mentioned for STxMP but not mentioned for CJT. There could be different understandings on the scope. At least it is not clear to us whether it is in scope or not.  Issue 1.2: We are fine with this design principle.  Issue 1.3: If our understanding is correct, we think it is addressing some cases where the number of TCI states indicated by DCI format 1\_1/1\_2 and the number of TCI states required by sTRP/mTRP schemes do not match. We support to study these, and we think a pre-defined association rule can be also considered.  Issue 1.4: We do not see the necessity, but we are open to discussing this. |
| Lenovo | Issue 1.1: We there are enough similarities between CJT and mTRP NCJT PDSCH to justify incorporating CJT in the R18 eUTI.  Issue 1.2: Excluding CJT, 2 sets of TCI states are sufficient to support mTRP schemes of R16/17.  Issue 1.3: It is not clear the question is raised at what level: DCI, MAC-CE or RRC? Please clarify.  Issue 1.4: This is in direct violation with the TCI framework of previous releases. We do not see a strong motivation for such configuration. |
| Fraunhofer IIS/HHI | Issue 1.1: TCI indication for CJT is not part of the WID. At the very least, we prefer that CJT considerations are not brought into the MTRP discussions regarding the number of indicated TCI states and the TCI-state mapping. If any agreement to support CJT is made, the discussions can be had with lower priority separate from the unified TCI framework for MTRP.  Issue 1.2: Agree in principle.  Issue 1.3: Slightly prefer to have it based on the MTRP scheme enabled.  Issue 1.4: Use-case unclear. Discussion should be of low priority. |
| Intel | Issue 1.1: CJT should use unified TCI framework and the beam indication aspects should be discussed in this agenda item since CSI is not going to discuss beam management. Otherwise, CJT may have to default to older TCI framework which would be unfortunate. RAN1 can further discuss whether 4 TCI states are needed to be indicated. We can agree to support CJT for eUTCI with the current agreement i.e., up to 2 TCI states as a starting point.  Issue 1.2: Not sure why we need to define “TCI Sets”. The formulation from last meeting i.e., combination of joint and or separate DL/UL TCI states is OK.  Issue 1.3: Motivation is unclear in current form. Based on MAC-CE codepoint, UE should be able to implicitly derive the number of TCI states to apply.  Issue 1.4: This should be supported in Rel-18. The restriction to configure via RRC in Rel-17 was an artificial one and was agreed due to no consensus in the case of single TRP, but for mTRP, we do not see why such restriction is needed. |
| CMCC | Issue1.1: We think unified TCI indication for CJT-based PDSCH reception(s) can be supported. Otherwise, UE may need fallback to R15/16 TCI state framework when CJT operation is applied.  Issue 1.2: We agree with FL that the related discussion is on-going in AI 9.1.2. We can discuss this issue when AI 9.1.2 has the decision for whether to prioritize or only support NTRP = {1,2} over {3,4}.  Issue 1.3: We think the exact number of applied TCI states should be determined per channel. But we should first discuss whether the number of indicated TCI states can be different with the TCI states be applied.  Issue 1.4: We think it can be supported. Since MPE issue may be occurred for only one of the TRPs, the TRP with MPE issue can use separate TCI mode, and the other TRP can use joint TCI mode. |
| SS | Issue 1.1: We are open to discuss beam indication aspects for CJT. As we commented in the last meeting, if needed, separate discussions on CJT and Rel-16/17 MTRP schemes can be carried out.  Issue 1.2: We are fine for the definition of TCI sets (for discussion purpose). Up to 2 TCI sets should be supported for the Rel-16/17 MTRP schemes extensions. We would like to ask for clarifications regarding possible TCI states combinations between the two sets if they are indicated (e.g., joint+joint, and etc.), and how this issue is related to Issue 1.4.  Issue 1.3: This issue is a bit unclear to us. To our understanding, this issue is about how to interpret/apply the indicated TCI states for different channels or different applications (otherwise, the number of indicated TCI states can be derived from the MAC CE activated TCI codepoints). As commented by other companies, the number of indicated TCI states applied in a CC/BWP can depend on the specific channel (e.g., one out the indicated two is used for SDCI PDCCH reception(s)) or a specific application scenario (e.g., dynamic STRP/MTRP switching or only one of the indicated TCI states gets updated). We are open to discuss how to interpret/apply the indicated TCI states based on a channel/RS type or (additional) indication.  Issue 1.4: The use cases of mixing the TCI types across TRPs are unclear to us. |
| FGI | Issue 1.1: Support of CJT operation for eUTCI framework might make the whole system consistent and complete. Thus, we suggest that we keep the CJT related discussion in this agenda but with lower priority than mTRP related discussion.  Issue 1.2: It may depend on the decision made for issue 1.1. We share the same view that the ‘TCI set’ is a little bit confusing.  Issue 1.3: The number of TCI states that UE needs to apply can be determined per-channel basis to ensure the scheduling flexibility. In other words, the number of TCI states can vary based on the applied channels, which shares the similar concept with Rel-16/Rel-17 mTRP operation.  Issue 1.4: In terms of providing greater flexibility, we support to update joint DL/UL TCI update and separate DL/UL TCI update in a same CC/BWP simultaneously, but the applicable scenarios should be further clarified considering the potential complexity. |
| LG | Issue 1.1: It seems better to focus on MTRP schemes in Rel-16/17 and STxMP schemes. If CJT needs to be considered, it should be low priority.  Issue 1.2: We agree with the FL’s assessment. For ‘TCI set’, it could be better to express ‘the combination of joint and/or separate TCI states’ to avoid the confusion of terminology.  Issue 1.3: It should be possible that the indicated TCI states via MAC-CE and/or MAC-CE + DCI can be differently applied for different channels/RSs or enabled MTRP schemes.  Issue 1.4: The use case needs to be clarified first for different mode of TCI state (joint/separate) across TRPs. |
| Xiaomi | Issue 1.1: since for issue 1.2, we support up to 2 sets of TCI states. And we think it can also be applied for CJT. It means that up to 2 TCI states can be used for CJT.  Issue 1.2: support up to 2 sets of TCI states.  Issue 1.3: we guess it means the number of indicated TCI states. According to FL’s summary, there are two alternatives. Alt 1 is to determine it based on MTRP schemes. Take joint TCI state as an example, if there is at least one channel configured as MTRP scheme, the number of joint TCI state will be always 2. And additional signaling will be used to indicate the mapping/association between the 2 indicated TCI states and each channel. Alt 2 is based on unified configuration scheme. It means that even at least one channel is configured with MTRP scheme, the number of indicated TCI state can be 1 when gNB schedules all channel as STRP transmission. In this case, the additional signaling to indicate the mapping/association will be unnecessary.  Issue 1.4: we think it can be supported for the case of DL only TRP/UL only TRP/MPE. |
| InterDigital | Issue 1.1: CJT specific issue should at least not be a dominating factor to progress this AI. In the following Issue 1.2 (suggested below), we can agree to support up to X indicated UTCIs which may not need to be based mainly on CJT usage at the first place. CJT specific issues should be treated separately (and with not a higher priority in this AI).  Issue 1.2: It’s confusing/premature and unnecessary to use the term “sets”. We can just reuse the last version of FL proposal (focused on what to support first) in the last meeting like:   * + Support up to X indicated joint TCI states in a CC/BWP for joint DL/UL TCI update   + Support up to X indicated DL TCI states and up to X indicated UL TCI states in a CC/BWP for separate DL/UL TCI update   X can be at least 2, and is not yet excluded to be more than 2 (e.g., for CJT use case, if agreed further).  This kind of principle on what to support is desired to be agreed first. And, further details on whether to be based on a sort of “set” structure can be discussed later.  Issue 1.3: It’s better to discuss more directly, case by case, after agreeing first on Issue 1.2. For example, if we agree on Issue 1.2, e.g., at least X=2, then, it means the UE can be indicated via a TCI codepoint of the TCI field in a DCI, where the TCI codepoint can be mapped to either one UTCI or two UTCIs (according to the MAC-CE activation which may need to be enhanced anyway). Then, how to enhance the MAC-CE and how to interpret the indicated 1 UTCI or X UTCIs can be further discussed, case by case, e.g., for STRP case, MTRP case, etc.  Issue 1.4: This can be discussed later in orders (at least after Issue 1.2). We tend to agree with views from CMCC and Xiaomi, in that no need to restrict gNB’s configurability to cope with various situations including MPE, MTRP usages, and so on. |
| Apple | Issue 1.1: In last meeting, it was agreed to target for ‘intra and inter-cell MTRP schemes specified in Rel-16 and Rel-17’ and ‘Rel-18 STxMP (if supported)’, which does not scope in the Rel-18 CJT use case. The standard effort needs to be carefully evaluated to add this into Rel-18 scope, taking into account limited TU.  Issue 1.2: In principle, we agree the procedure for sDCI-based mTRP. But, no need of ‘TCI set’ concept even for discussion purpose. For mDCI-based mTRP, the Rel-17 unified TCI framework can be fully reused for each TRP including RRC-based TCI state list configuration, MAC-CE based TCI association and DCI-based TCI update.  Issue 1.3: In our view, Rel-17 three-stage approach can be reused by combining RRC+MAC+DCI signaling. The exact number of TCI states can up to 4 for sDCI-based mTRP (e.g., separate DL/UL mode where 2 TCI state per TRP) and up to 2 for mDCI-based mTRP.  Issue 1.4: We are generally supportive for this combination due to potential flexibility benefit e.g., when MPE issue occurs for one TRP, instead of both. |
| Futurewei | **Issue 1.1:** We support applying the unified TCI framework extension in Rel. 18 to CJT. Our view is that supporting multi-TRP and CJT schemes with one unified TCI framework will reduce system complexity.  **Issue 1.2:** The term “TCI set” is unclear and needs clarification.  **Issue 1.3:** Our view is that the TCI states that a UE needs to apply to a channel/signal should be decided based on a combination of RRC configuration, MAC CE activation, and DCI indication.  **Issue 1.4:** We fail to see a strong motivation to support one TRP with joint DL/UL TCI update and another with separate DL/UL TCI update. |
| Huawei, HiSilicon | Issue 1.1 In RAN1#109e, it has been agreed that up to four cooperating TRPs are supported for CJT based CSI report in FR1. Although TRPs may perform CJT transmission to each UE, we don’t think transmission of a single coherent TRS would be a practical solution to estimate the delay spread of all links: Different UEs are associated with different TRP sets and transmitting TRS coherently means that UE-specific coherent TRS is needed, which introduces a large TRS overhead in MU-MIMO scenario. Therefore, cell-specific non-coherent TRS in which one TRS is associated with one TRP is a more reasonable method to reduce TRS overhead. It means that, in general, for a CJT with four TRPs, up to 4 joint or DL TCI states should be indicated; at least for FR1.  Issue 1.2 We don’t think we need to specify “TCI sets”. We may use this terminology only to facilitate discussion. Further, our strong preference is to first conclude the issue 1.1. In its current form, we cannot agree with “up to 2 sets of TCI states (TCI set)” in Issue 1.2. We are generally OK with the last bullet of Issue 1.2 as it follows the same design as in Rel-17 unified TCI.  Issue 1.3 We are not sure we clearly understand the intention of the question. In Rel-17, depending on the activation MAC-CE and the TCI codepoint in DCI, one or two TCIs are applied for a single TRP. In Rel-18, and assuming two TRPs in FR2, a similar principle can be used: depending on the activation command(s) and TCI codepoint(s) in DCI(s), up to 4 TCIs are applied.  Issue 1.4 We think joint DL/UL TCI update and separate DL/UL TCI update can be supported in a same CC/BWP simultaneously. Extending the unified TCI framework to mTRP requires indicating m (pairs of) TCI states to the UE. It is possible that the UL and DL beam correspondence may hold only for some of the m beam pair links (in FR2, m=2). As an example, the MPE restriction may only be applicable to one UE panel whose UL beam is towards a single TRP. In such a case, the beam pair link between UE’s other panel and other TRP(s) should not be impacted. It is therefore beneficial to support per TRP TCI state mode configuration for the sake of transmission flexibility. |
| CATT | Issue 1.1: We prefer to focus on Rel-16/17 mTRP and STxMP in this agenda item. It seems that the question on whether 4 TCI states are needed is related to CJT only. So, as commented by FL for issue 1.2, we also think it’s better to discuss CJT separately.  Issue 1.2: We are fine with the definition of TCI set. Alternatively, the formulation used in the last meeting, i.e., combination of joint and or separate DL/UL TCI states, is also acceptable to us.  Issue 1.3: This issue is not quite clear to us. For flexibility, the number of applied TCI states per CC/BWP should be determined per channel. Namely, each channel could determine its sTRP or mTRP transmission separately. For sTRP, only one TCI set is applied. For mTRP, two TCI sets should be applied.  Issue 1.4: As mentioned by some other companies, for mTRP, it is possible that one link may suffer from MPE and the other one does not. Then, hybrid configuration of joint TCI and separated DL/UL TCI seems necessary to be supported in Rel-18. |
| Spreadtrum | Issue 1.1: CJT aims to FR1 and is not included in WID, so we fail to see a strong motivation to study the TCI indication for CJT.  Issue 1.2: Supportive about the design principle.  Issue 1.3: To determine the exact number of TCI states, the number of RRC-configured TCI states and the MAC CE format design should be discussed firstly, then, the number of exact applied TCI states can be determined per channel according to different transmission scheme.  Issue 1.4: negative about the issue, since the use case is unclear. |
| QC | For 1.1, we think it would be good to align on the following issues. In short, we believe either 1 TCI state or SFN-PDSCH with multiple TCIs can work. For SFN-PDSCH, we prefer to stick to max TCI # of 2. Up to 4 can be considered if we have more time.   * Issue 1: For CJT, whether every PDSCH DMRS port should have the same set of TCI(s)?   + Our preference is Yes. To our understanding, CJT means each stream is always precoded across ALL TRPs, not only across a subset of TRPs, which is NCJT. So it is sensible for same set of TCI(s) applied to every DMRS port, which is transmitted by all TRPs. This is not like R16 SDM NCJT that different TCIs applied to different CDM groups. * Issue 2: For CJT, what is the suitable TCI indication schemes?   + If same set of TCI(s) are applied to every DMRS port, we think both 1 TCI state are SFN-PDSCH can work. The 1 TCI state is essentially SFN-TRS, where a single TCI is applied to all DMRS ports with the corresponding TRS jointly transmitted by all TRPs. The SFN-PDSCH can be viewed as an extension of R17 SFN-PDSCH with maximum TCI state number increased from 2 to 4. However, the design for supporting up to 4 indicated TCI states is non-trivial, and we prefer to limit the maximum indicated TCI state number to be 2 for all considered mTRP schemes in R18. Open to extension for 4 TCIs if having more time.   **Proposal: For unified TCI framework extension to FR1 CJT, SFN-TRS and SFN-PDSCH can be considered**   * **In SFN-TRS, a single TCI state is applied to all DMRS ports with the corresponding TRS jointly transmitted from all TRPs** * **In SFN-PDSCH, a same set of TCI state(s) can be applied to all DMRS port(s) with the maximum number of TCI states in the set as 2**   For 1.2, support up to 2 TCI sets. Our understanding is that the set here is for discussion purpose. Up to 4 TCI sets can be studied if have time. 2 TCIs for CJT can also work for the scenario with 2 TRP groups with closely located TRPs per group, like sectors. Open to consider 4 widely separately TRPs but with lower priority.  For 1.3. I guess the question means that when 2 TCIs are indicated, how to determine the TCI(s) per applied channel/RS per BWP/CC? If so, our preference is to individually determine the TCI # for each channel/RS. For example, for RRC configured channel/RS, gNB can also configure whether this channel/RS should use the 1st, 2nd, or both indicated TCI. For dynamically scheduled channel/RS, the DCI can indicate whether the scheduled channel/RS should use the 1st, 2nd, or both indicated TCI  For 1.4, we support no restriction on the combination of TCI types across two TRPs. For Joint TCI for TRP 1 + separate DL/UL TCI for TRP 2, this would be beneficial in the scenario where one TRP, e.g. TRP 2 in the following figure, has the best DL beam suffering MPE issue, while the other TRP does not. To our understanding, every combination seems have its use case.    **Figure: One TRP has the best DL beam suffering MPE issue, while the other TRP does not** |
| Mod | One clarification for my plan in this meeting. Not only Issue 1, I will treat those important topics in parallel for Issue 1, 2, 3, and 4, mostly based on the following table (I have revised some topics and changed the order according to your feedback):    The following is my observation from your input and good discussion:  On Issue 1.1: It seems it is still quite controversial. We can continue the discussion in this meeting, and a proposal will be provided accordingly.  On Issue 1.2: Most of the companies are fine with those max numbers proposed for target use cases we agreed in RAN1#109e, but several companies have concern on the terminology of “TCI set”. Although my intension is for facilitating discussion, it will be better to focus on the maximum numbers first. A proposal will be provided accordingly, without using of “TCI set”.  On Issue 1.3: Based on the inputs from companies, one potential outcome of this issue would be that the exact number of TCI states that UE needs to apply in a CC/BWP can be determined according to both of the followings:   * The number of TCI states indicated by MAC-CE/DCI analogous to Rel-17 TCI state activation and update procedure * The number of TCI states associated with each channel/RS based on an association signaling/rule   Then, since the association doesn't have to be provided through the TCI state indication, one question came up naturally is whether the number of TCI states indicated to a BWP can be different from the total number of TCI states associated with channels/RSs in the BWP? If it is allowed, what’s the UE behavior? This question could be a next-level detail, and we can discuss it later if this group has more conclusions on Issue 3.  On Issue 1.4: For the proponent of supporting mixed TCI update modes for two TRPs simultaneously in the same CC/BWP, the main motivation is that there could be only one of the TRPs suffering from MPE issue. Opponents can further clarify how to handle such case if mixed TCI update modes in a same CC/BWP are not allowed. |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | RP-213598 | New WID: MIMO Evolution for Downlink and Uplink | Samsung |
| 2 | [R1-2206975](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206975.zip) | Multi-TRP enhancements for the unified TCI framework | Fraunhofer IIS, Fraunhofer HHI |
| 3 | [R1-2206995](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206995.zip) | Unified TCI framework extension for multi-TRP | MediaTek Inc. |
| 4 | [R1-2207393](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207393.zip) | Discussion on unified TCI framework extension for multi-TRP | NTT DOCOMO, INC. |
| 5 | [R1-2207320](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207320.zip) | Unified TCI framework extension for multi-TRP | Apple |
| 6 | [R1-2207215](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207215.zip) | Extension of unified TCI framework for mTRP | Qualcomm Incorporated |
| 7 | [R1-2207265](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207265.zip) | Unified TCI framework extension for multi-TRP | Panasonic |
| 8 | [R1-2207444](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207444.zip) | Discussion on unified TCI framework extension for multi-TRP | ITRI |
| 9 | [R1-2207450](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207450.zip) | Unified TCI framework extension for multi-TRP | Sharp |
| 10 | [R1-2207065](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207065.zip) | Discussion on Unified TCI framework extension for multi-TRP | CEWiT |
| 11 | [R1-2207544](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207544.zip) | Unified TCI framework extension for multi-TRP | Nokia, Nokia Shanghai Bell |
| 12 | [R1-2206110](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206110.zip) | Considerations on unified TCI framework for multi-TRP | Sony |
| 13 | [R1-2206161](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206161.zip) | Discussion on unified TCI extension for mTRP | Fujitsu |
| 14 | [R1-2206024](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206024.zip) | Discussion on unified TCI framework extension for multi-TRP | vivo |
| 15 | [R1-2206263](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206263.zip) | Unified TCI framework extension for multi-TRP | OPPO |
| 16 | [R1-2206246](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206246.zip) | Unified TCI framework extension for multi-TRP | Ericsson |
| 17 | [R1-2206209](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206209.zip) | Discussion of unified TCI framework for multi-TRP | Lenovo |
| 18 | [R1-2205981](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205981.zip) | Discussion on unified TCI framework extension for multi-TRP | Spreadtrum Communications |
| 19 | [R1-2205918](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205918.zip) | Enhancements on unified TCI framework extension for multi-TRP | ZTE |
| 20 | [R1-2205879](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205879.zip) | Discussion on unified TCI framework extension for multi-TRP | Huawei, HiSilicon |
| 21 | [R1-2205747](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205747.zip) | Unified TCI framework extension for multi-TRP | FUTUREWEI |
| 22 | [R1-2205816](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205816.zip) | Discussion on Unified TCI Extension for MTRP | InterDigital, Inc. |
| 23 | [R1-2205825](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205825.zip) | Discussion on unified TCI framework extension for multi-TRP operation | TCL Communication Ltd. |
| 24 | [R1-2206484](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206484.zip) | Discussion on unified TCI framework extension for multi-TRP | Google |
| 25 | [R1-2206620](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206620.zip) | Unified TCI framework extension for multi-TRP | Xiaomi |
| 26 | [R1-2206570](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206570.zip) | Unified TCI framework for mTRP | Intel Corporation |
| 27 | [R1-2206375](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206375.zip) | Discussion on unified TCI framework extension for multi-TRP operation | CATT |
| 28 | [R1-2206463](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206463.zip) | Discussion on unified TCI framework extension for multi-TRP | NEC |
| 29 | [R1-2207096](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207096.zip) | Discussion on unified TCI framework extension for multi-TRP | FGI |
| 30 | [R1-2206667](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206667.zip) | Enhancement on unified TCI framework for multi-TRP | Transsion Holdings |
| 31 | [R1-2206866](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206866.zip) | Unified TCI framework extension for multi-TRP/panel | LG Electronics |
| 32 | [R1-2206894](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206894.zip) | Discussion on unified TCI framework extension for multi-TRP | CMCC |
| 33 | [R1-2206810](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206810.zip) | Views on unified TCI extension focusing on m-TRP | Samsung |