**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 2)

**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:

|  |
| --- |
| **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

R1-2207735 Moderator summary on extension of unified TCI framework (Round 0) Moderator (MediaTek)

R1-2207928 Moderator summary on extension of unified TCI framework (Round 1) Moderator (MediaTek)

R1-2208075 Moderator summary on extension of unified TCI framework (Round 2) Moderator (MediaTek)

# 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, Futurewei, Nokia (in principle, UTCI framework should cover all scenarios)Concern: vivo, NEC, Fujitsu, IDC, Apple, Spreadtrum, Qualcomm (ok for SFN), LGOut-of-scope: OPPO, Fraunhofer | Proposal 1.A is provided for this issueNote 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), Docomo (prefer to keep FFS for >2)Concern:  | Proposal 1.B is provided for this issueNote 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, Docomo, NEC, IDC, TransHoldConcern: Google, OPPO, Lenovo, LG, Spreadtrum, Nokia, MediaTek, Fraunhofer, ZTE | 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, Huawei/HiSilicon, IDC, Futurewei, LG, vivo, TransHold, Nokia, Intel, CMCCAtl2-Introduce TRP-specific TCI state list(s): Apple (M-DCI), CATT (M-DCI), ZTE, Spreadtrum, TCL, Google Docomo (M-DCI), NEC | 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, ZTEConcern: Ericsson, MediaTek, Apple, Docomo, Nokia, CATT, OPPO, LG, Intel, Huawei/HiSilicon, Lenovo, vivo |  |

**Proposal 1.A**: On unified TCI framework extension, up to X (X > 1) joint/DL TCI states can be applied simultaneously to CJT-based PDSCH reception, where the UE shall assume that the PDSCH DM-RS port(s) is QCLed with the DL RSs of the joint/DL TCI states

* FFS: Whether this can be supported based on current specification (e.g., PDSCH-SFN) w/o change
* FFS: PDSCH DM-RS port(s) is QCLed with the more than one joint/DL TCI states with what QCL type(s)
* FFS: RAN1 to make decision in RAN1#110bis-e on the value of X
* Note: CJT in Rel-18 targets only FR1

# 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 MTRPAlt1: Reuse the same TCI state update scheme for S-DCI based MTRPAtl2: 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* valueAlt3: 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* valuesAlt4: 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, IDC(as unified design)Alt2: Apple, Nokia, CATT, CEWiT, CMCC, Docomo, MediaTek, FGI, Fraunhofer, Fujitsu, Futurewei, Huawei/HiSilicon, Intel, LG, OPPO, Panasonic, Qualcomm, Samsung. Sharp, vivo, NEC, IDC(as default), LenovoAlt3: FGI, TransHoldAlt4: ZTE, FGI, Fraunhofer, Spreadtrum, TransHold, Xiaomi, Google, IDC (depending on MAC-CE) | Given the majority view, Proposal 2.A is recommended for this issueHow 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, NEC, LGConcern: Intel, QC, OPPO, vivo, TransHold |  |
| 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, SamsungConcern: Futurewei, Lenovo, OPPO (not for joint DL/UL TCI update), vivo, QC, Huawei/HiSilicon, IDC, TransHold |  |

**Proposal 2.A-1:** On unified TCI framework extension for M-DCI based MTRP, RAN1 to make decision on support ~~only Option 1 or support both~~ one of the following options in RAN1#110bis-e:

* Option 1: 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 the joint/DL/UL TCI state(s) associated with the same *coresetPoolIndex* value
	+ The UE shall apply the joint/DL/UL TCI state(s) associated with a *coresetPoolIndex* value to channel(s)/signal(s) that have explicit or implicit association with the *coresetPoolIndex* value
* Option 2: 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 the joint/DL/UL TCI state(s) associated with the same or different *coresetPoolIndex* value
	+ The UE shall apply the joint/DL/UL TCI state(s) associated with a *coresetPoolIndex* value to channel(s)/signal(s) that have explicit or implicit association with the *coresetPoolIndex* value
	+ FFS: Detail of signaling

# 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 MTRPAtl1: Use RRC configuration to inform the mapping/association between a configured or indicated joint/DL TCI state and a CORESET or a CORESET groupAlt2: Use RRC configuration to inform the mapping/association between a configured or indicated joint/DL TCI state and a search space setAlt3: Use MAC-CE to inform the mapping/association between an activated or indicated joint/DL TCI state and a CORESET or a CORESET groupAlt4: Use DCI to inform the mapping/association between an indicated joint/DL TCI state and a CORESET or a CORESET groupAlt5: 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), TransHold, Intel, FGIAlt2: Apple, EricssonAlt3: Google, Huawei/HiSilicon (switching between SFN and non-SFN), Xiaomi, IDCAlt4:Alt5: Nokia (STRP and PDCCH-SFN), CEWiT, Huawei (PDCCH repetition), Fujitsu (STRP), Futurewei, Intel, ITRI, Lenovo, OPPO, Panasonic, Samsung (PDCCH repetition), IDC | 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, LG, TransHold, FGIAlt1-1-Reuse existing TCI field (number of indicated joint/DL TCI state(s)) in the scheduling DCI: OPPO, FraunhoferAlt2-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, ZTE, LG, FGIAlt2-Follow the spatial domain transmission filter(s) used for 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, ZTE, LG, vivoAlt2-Use a MAC CE-based association: CATT, Huawei/HiSilicon (switching between repetition and non-repetition), XiaomiAlt3-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, Docomo, ZTEAlt2-Reuse the same association scheme for S-DCI based MTRP: Ericsson | Whether PDCCH repetition/SFN can be supported together in M-DCI based MTRP can be further discussed |

**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 at least one alternative from the followings:

* Alt1: Use an indicator field other than the existing TCI field (could be reusing an existing DCI field or introducing a new DCI field) in a DCI format 1\_1/1\_2 with DL assignment 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: Joint/DL TCI state(s) applying to PDSCH reception scheduled/activated by DCI format 1\_0
* Alt2: Use an indicator field other than the existing TCI field (could be reusing an existing DCI field or introducing a new DCI field) in a DCI format 1\_1/1\_2 with and without DL assignment to inform which indicated joint/DL TCI state(s) the UE shall apply to all PDSCH receptions after an application time
	+ FFS: Detail of the application time
* Alt3: Reuse the existing TCI field in a DCI format 1\_1/1\_2, i.e., the UE shall apply the joint/DL TCI state(s) mapped to the TCI codepoint indicated by the DCI format 1\_1/1\_2 to PDSCH reception scheduled/activated by the DCI format 1\_1/1\_2 if the PDSCH reception is scheduled/activated after the beam application time as defined in Rel-17
* Alt4: Use 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
* Alt5: Use 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(s) is associated with each CORESET group. When a scheduling/activation DCI with DL assignment is received in a CORESET group, the indicated joint/DL TCI state(s) associated with the CORESET group is applied to PDSCH reception scheduled/activated by the scheduling/activation DCI.

# 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, Docomo, Apple, LG, vivo, Intel, FGIAlt2-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~~Alt4- Not support any default rule for the case that one or both indicated joint/UL TCI state(s) is not associated with an UL PC parameter setting: ZTE | 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, Docomo, vivoConcern: Huawei/HiSilicon |  |

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

* Alt1: Support two default UL PC parameter settings configured in *BWP-UplinkDedicated*, and the UE should apply the one or two default UL PC parameter settings configured in the corresponding UL BWP
	+ FFS: 1-to-1 association between an indicated joint/UL TCI state and a default UL PC parameter setting
* Alt2: No change from Rel-17 unified TCI framework, i.e., the UE should apply the one single default UL PC parameter setting configured in the corresponding UL BWP regardless the UL PC parameter setting is absent from one or both of indicated joint/UL TCI states
* Alt3: A joint/UL TCI state for PUCCH/PUSCH transmission is always associated with a UL PC parameter setting for PUCCH/PUSCH

**Support/fine: CATT, vivo, TransHold, Intel, FGI, Lenovo, Fujitsu, CMCC, ZTE, Sharp, NTT DOCOMO, QC, Huawei, HiSilicon**

**Not support: Ericsson**

# 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, Docomo, ZTE, vivo, NokiaConcern: OPPO, Huawei/HiSilicon | 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, Docomo, NEC, ZTE, IDC, LG, NokiaConcern: Huawei/HiSilicon | 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, Huawei/HiSilicon, Docomo, NEC, ZTE, IDC, vivo, NokiaConcern: |  |

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**
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| QC | Support 3.1 and 3.2, but fine to wait till STxMP decision is clearSupport 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. |
| Huawei, HiSi | **3.1 and 3.2:** We agree with the moderator and prefer to wait the progress of 9.1.4.1.**3.3: W**e support such enhancement. |
| Docomo | Our views added in the table. For 3.1 and 3.2, we support the enhancements on beam reporting to support STxMP, and fine to wait for progress in 9.1.4.1.For 3.3, we support to study it. |
| NEC | We support to have enhancements as said in 3.2 and 3.3 |
| ZTE | Our views are provided in the table. BTW, for group based reporting, we think that, for STxMP, the UE capability report should be based on group based report rather than non-group.  |
| InterDigital | Our views are updated in the table. |
| Futurewei | For Issues 3.1 and 3.2, we agree with moderator that the discussions should wait for decisions in agenda item 9.1.4.1. |
| Samsung | We prefer to complete STxMP discussion before go into details for 3.1 or 3.2. And we prefer 3.1 as staring point, if STxMP is supported. Support 3.3. |
| Xiaomi | Support 3.1 and 3.2, ok to discuss the details till STxMP is agreed. Support 3.3 for mTRP case. |
| CATT | Support 3.1 and 3.2.For Issue 3.3, detailed issues to be discussed need to be clarified. |
| vivo | Agree with Moderates’ notes. |
| TransHold | Support 3.1 and 3.2, fine to discuss the details till STxMP is agreed. For 3.3, we support to study it. |
| Nokia | 3.1 and 3.2: Enhancement to beam reporting is needed to provide network information about feasibility of STxMP but this can discussed when STxMP schemes are more clear.3.3: enhancements needed to BFR operation should be studied to cover the unified TCI extension to mTRP BFR specified in R17. |
| Ericsson | Issue 3.1: This has nothing to do with the unified TCI framework: it’s a reporting enhancement.Issue 3.2: Nothing to do with the unified TCI framework. Having said that, we have concerns on (some) extensions of the capability index reporting.Issue 3.3: Low prio. Editorial updates can be considered. |
| CMCC | For 3.1 and 3.2, we think they are important issues to facilitate STxMP, but we are not sure whether they should be discussed in unified TCI framework.For 3.3, agree with Ericsson. Editorial updates can be considered. |

# 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** |
| Huawei, Hisilicon | Considering enhancements for common TCI state update for mTRP where sTRP and mTRP CCs can be configured in the same CC list. |

# 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 agreedNote: Scenarios of above include at least single carrier scenario for FR2Note: Above power limitation includes both total radiated power and EIRPLS to RAN4 is endorsed in R1-2205639. |
| **RAN1#110** |
| **Agreement**On unified TCI framework extension for S-DCI based MTRP, 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:* Alt1-1: Use RRC parameter(s) in a CORESET configuration to inform the UE whether and/or which indicated joint/DL TCI state(s) shall be applied 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: Use 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(s) is 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)
	+ FFS: How to associate the indicated joint/DL TCI state(s) with each CORESET group
	+ FFS: The UE applies the indicated joint/DL TCI state(s) to a CORESET according to the CORESET group(s) the CORESET belongs to, or the UE applies the indicated joint/DL TCI state(s) associated with the CORESET group(s) in which the beam indication DCI is received to all PDCCH receptions
* Alt2: The association between a CORESET and the indicated joint/DL TCI state(s) is determined based on a fixed rule, and the UE shall apply the indicated joint/DL TCI state(s) 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
* Alt3: Use MAC-CE to inform the UE whether and/or which indicated joint/DL TCI state(s) shall be applied to the corresponding PDCCH receptions on a 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

Switching between multi-TRP and single TRP operation is not precluded**Agreement**On unified TCI framework extension, for the target use cases agreed in RAN1#109-e in AI 9.1.1.1, up to 4 TCI states can be indicated in a CC/BWP or a set of CCs/BWPs in a CC list to DL receptions and/or UL transmissions, where these TCI states are indicated/updated by MAC-CE/DCI with the necessary MAC-CE based TCI state activation* FFS: The possible combination(s) of joint/DL/UL TCI states that can be indicated to DL receptions and/or UL transmissions in a BWP/CC/TRP
* Note: This agreement does not imply that there will be more than 2 DL or UL or joint TCI states indicated in a CC/BWP for the target use cases agreed in RAN1#109-e in AI 9.1.1.1
* Note: The maximum number of TCI states that can be indicated to each of the target use cases agreed in RAN1#109-e in AI 9.1.1.1 is remained the same as in Rel-16/17

Note: The maximum number of TCI states that can be indicated simultaneously to CJT-based PDSCH reception and the required type(s) of TCI states (i.e., DL /UL/joint) are independently discussed in this AI**Agreement**On unified TCI framework extension for S-DCI based MTRP, for PUSCH transmission scheduled/activated by a DCI format 0\_1/0\_2, down-selection one alternative from the followings:* Alt1: Use an indicator field (could be reusing an existing DCI field or introducing 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 spatial domain transmission filter(s) used for the SRS resource(s) indicated by the DCI format 0\_1/0\_2
* Alt3: Use an RRC parameter in a CORESET configuration to inform that the CORESET belongs to which CORESET group(s), and the indicated joint/UL TCI state(s) is associated with each CORESET group. When a scheduling/activation DCI format 0\_1/0\_2 is received in a CORESET group, the indicated joint/UL TCI state(s) associated with the CORESET group is applied to PUSCH transmission scheduled/activated by the DCI format 0\_1/0\_2
	+ FFS: Details of CORESET group(s)

FFS: PUSCH transmission scheduled/activated by a DCI format 0\_0 and Type-1 CG-PUSCH**Agreement**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:* Alt1: Use RRC configuration to inform the association between the indicated joint/UL TCI state(s) and a PUCCH resource/ group
* Alt2: Use RRC configuration to inform the association between a CORESET group and a PUCCH resource/group, and the indicated joint/UL TCI state(s) associated with the CORESET group applies to the PUCCH resource/group
* Alt3: Use MAC-CE to inform the association between the indicated joint/UL TCI state(s) and a PUCCH resource/group
* Alt4: Use DCI to inform the association between the indicated joint/UL TCI state(s) and a PUCCH resource/group
 |

# Appendix B: Proposal Pool

**Proposal 1.B**: On unified TCI framework extension, up to 4 TCI states can be applied to DL receptions and/or UL transmissions 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 to DL receptions and/or UL transmissions in a CC/BWP for MTRP operation:
	+ 2 joint TCI states for joint DL/UL TCI update in the CC/BWP
	+ 2 pairs of DL and UL TCI states for separate DL/UL TCI update in the CC/BWP
	+ 1 pair of DL and UL TCI states + 1 DL TCI state for separate DL/UL TCI update in the CC/BWP
	+ 1 pair of DL and UL TCI states + 1 UL TCI state for separate DL/UL TCI update in the CC/BWP
* In addition to the above combinations, study whether to support the following combinations:
	+ 3 joint TCI states for joint DL/UL TCI update in the CC/BWP
	+ 4 joint TCI states for joint DL/UL TCI update in the CC/BWP
	+ 1 joint TCI state for joint DL/UL TCI update in the CC/BWP + 1 pair of DL and UL TCI states for separate DL/UL TCI update in the same CC/BWP
	+ 1 joint TCI state for joint DL/UL TCI update in the CC/BWP + 1 DL TCI state for separate DL/UL TCI update in the same CC/BWP
	+ 1 joint TCI state for joint DL/UL TCI update in the CC/BWP + 1 UL TCI state for separate DL/UL TCI update in the same CC/BWP
* 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
* Note: As in Rel-17, a joint TCI state in any above combination is applied for UL transmission only if applicable
* FFS: The possible combination(s) of joint/DL/UL TCI states that can be applied per TRP

**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

* The UE shall apply the joint/DL/UL TCI state(s) associated with a *coresetPoolIndex* value to channel(s)/signal(s) that have explicit or implicit association with the *coresetPoolIndex* value
* FFS: Whether and how to indicate the joint/DL/UL TCI state(s) associated with another *coresetPoolIndex* value, e.g., reusing the same TCI state update scheme for S-DCI based MTRP or the DCI format 1\_1/1\_2 can inform the indicated joint/DL/UL TCI state(s) is associated with which *coresetPoolIndex* value

**Support (21): Qualcomm, OPPO, Huawei/HiSilicon, Docomo, NEC, Spreadtrum, Fraunhofer, Futurewei, Lenovo, Apple, LG, CATT, vivo, Nokia, Intel, Panasonic, FGI, Fujitsu, CMCC, ZTE, CEWiT**

**Not support (6): Google, InterDigital, Xiaomi, TransHold, Samsung, Ericsson**

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| 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 |
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| 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 |
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