**3GPP TSG RAN WG1 #109-e R1-2205314**

**e-Meeting, May 9th – 20th, 2022**

**Agenda item:** 9.1.1.1

**Source:** Moderator (MediaTek)

**Title:** Moderator summary on extension of unified TCI framework for MTRP (Round 3)

**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. … 2. 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. 3. … 4. … 5. … 6. 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. 7. 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]-[31], the followings are provided in this document:

* Summary of companies’ views on each of open issues raised by interested companies
* Observation and recommended proposal based on the summary of companies’ views

**Round 3 is intended to prepare the group for the GTW discussion on Friday May 20th 03:00 UTC.**

**Share your inputs before Thursday May 19th 23:59 UTC, would be appreciated.**

# Issue 1 – Extension of Unified TCI Framework

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

Table 1 Summary for Issue 1

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| **#** | **Issue** | **Companies’ views** | **FL note/observation** |
| 1.3 | Max number of indicated joint TCI states (M1) for joint DL/UL TCI update  Max number of indicated DL TCI states (M2) for separate DL/UL TCI update  Max number of indicated UL TCI states (N2) for separate DL/UL TCI update | Atl1: M1 = 2, M2 = 2, N2 = 2   * Support: Samsung, Docomo, OPPO, Apple, Qualcomm, Intel, Nokia, ZTE, MTK, InterDigital, CATT, Spreadtrum, Sony, LGE, ITRI, TransHold, Fraunhofer, Fujitsu, Huawei, FGI, AT&T   Atl2: M1 > 2, M2 > 2, N2 > 2   * Support: Ericsson (up to 4 indicated joint, DL, and/or UL TCI states) | From moderator’s observation, {M1, M2, N2} = {2, 2, 2} is sufficient to support MTRP operation, which is the use case that should be focused on according to the WID. Another potential use case (separate control and data beams) has been proposed in one contribution, however, {M1, M2, N2} = {2, 2, 2} doesn't prevent that use case. {M1, M2, N2} = {2, 2, 2} is incapable only when both use cases work at the same time (i.e., MTRP + separate control and data beams per TRP-link), but whether such direction is still within the scope defined in the WID is doubtful. Since these max numbers could impact the later designs a lot, moderator suggests concluding them as early as possible. Given the majority view, Proposal 1.B is recommended.  How to configure/determine the exact number of indicated joint/DL/UL TCI states can be further discussed |
| 1.4 | The multiple indicated joint/DL/UL TCI states are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation (analogous to Rel-17 procedure) | Support: Ericsson, Samsung, Docomo, OPPO, ZTE, vivo, Apple, Qualcomm, MTK, InterDigital, CATT, Futurewei, Spreadtrum, Sony, Xiaomi, LGE, Lenovo, CMCC, TransHold, Fraunhofer, Fujitsu, Nokia (s-DCI mode), FGI, AT&T, Intel  Concern: | Given the majority view on this issue, Proposal 1.B is recommended accordingly.  Details of TCI state update and activation are discussed in the following sub-issues |
| 1.5 | Individual TCI update mode (joint or separate DL/UL TCI update) for each TRP, i.e., one TRP with joint DL/UL TCI update and another with separate DL/UL TCI update | Support: Nokia (m-DCI mode), Qualcomm, , CATT, Sony, Xiaomi, ITRI, FGI, Intel, InterDigital  Concern: Apple (no use case), ZTE, OPPO |  |
| 1.6 | TCI state update for S-DCI based MTRP | Use existing (single) TCI field in DCI to update all or subset of indicated TCI states:   * Support: Ericsson, Samsung (DCI w/ DLA), Docomo, OPPO (DCI w/ DLA), Apple, Qualcomm, Intel, ZTE, vivo, InterDigital, CATT, TransHold, Futurewei, Spreadtrum, Sony, CEWiT, MTK, Nokia, Fujitsu, LG, AT&T * Concern:   More than one TCI fields in DCI w/o DLA and each TCI field can update indicated TCIs respective to one of the TPRs:   * Support: Samsung, FGI, LG * Concern: Apple (DCI overhead), Intel | Given the majority view on this issue, Proposal 1.C is recommended accordingly.  How to activate TCI states for indicated TCIs states can be discussed after the update scheme is sufficiently mature  If single TCI field in DCI is agreed, whether to increase the max number of codepoints/bits can be further discussed  If single TCI field in DCI is agreed, whether the switching between S-TRP and M-TRP is determined from the number of TCI states associated with the indicated codepoint can be further discussed |
| 1.7 | TCI state update for M-DCI based MTRP | Alt1: Use existing (single) TCI field in DCI associated with one of *CORESETPoolIndex* values to update the indicated TCI states respective to the *CORESETPoolIndex* value (i.e., no cross-TRP beam indication)   * Support: Samsung, Nokia, Docomo, Qualcomm, Intel, ZTE, vivo, MTK, Xiaomi. LGE, Fraunhofer, FGI, OPPO, Fujitsu, TransHold * Concern: Apple, Ericsson   Alt2: Use existing (single) TCI field DCI associated with one of *CORESETPoolIndex* values to update the indicated TCI states respective to both *CORESETPoolIndex* values (i.e., cross-TRP beam indication can be supported)   * Support: Apple, Xiaomi * Concern: Docomo (not good in non-ideal backhaul), Ericsson, InterDigital, Intel | Two alternativities for potential down-selection are provided by Proposal 1.D  How to activate TCI states for the indicated TCI states can be discussed after the update scheme is sufficiently mature |
| 1.8 | DCI format for updating the indicated TCI stares | Alt1: Reuse the same DCI formats as in Rel-17 (i.e., DCI formats 1\_1/1\_2 with or without DLA), and no additional DCI format is introduced   * Support: ZTE, vivo, CATT, Apple, OPPO Docomo, Nokia, Ericsson, Fujitsu, LG * Concern:   Atl2: In addition to the DCI formats used in Rel-17, introduce DCI formats 0\_1/0\_2 for updating at least the indicated UL TCI states:   * Support: Xiaomi, Intel, FGI, LG * Concern: Docomo, Ericsson, Spreadtrum |  |
| 1.9 | RRC-configured TCI state lists | Alt1: Reuse Rel-17 design (i.e., one TCI state list for joint/DL TCI states and one TCI state list for UL TCI states)   * Support: Ericsson, MTK, Docomo (if the max # of configured TCI states is not increased for MTRP), Nokia, Fraunhofer, Xiaomi, OPPO, Fujitsu, Intel * Concern: Apple (not good for TCI pool sharing for CCs with different sTRP/mTRP operation)   Atl2: TRP-specific TCI state list(s)   * Support: ZTE, Apple, vivo (if individual TCI update mode is allowed for each TRP), Docomo (if the max # of configured TCI states is increased for MTRP), FGI * Concern: Ericsson   Increase the max number of configured joint/DL/UL TCI states for MTRP operation   * Support: * Concern: | For this sub-issue, Proposal 1.H is recommended accordingly |
| 1.10 | Introduction of TRP-ID associated with or included in each TCI state | Support: CMCC, Spreadtrum, ZTE (still case-by-case)  Concern: Ericsson, MTK, Apple, Docomo, Nokia, CATT, OPPO, LG, Intel |  |
| 1.11 | Applying/mapping the indicated TCI states to channel/signals for S-DCI based MTRP | To inform to the UE at least which one or two indicated TCI states (or which one or two TRPs) is mapped to the corresponding channel(s)/signal(s), an indicator is introduced:   * Per CORESET or per search space set: Ericsson, Xiaomi, ZTE, vivo, CATT, Nokia, MTK, Qualcomm, Samsung, Apple (CORESET), Docomo, FGI, OPPO (per CORESET), Fujitsu, LG, Intel (CORESET) * Per DCI with DL assignment for the scheduled/activated PDSCH: ZTE, vivo, MTK, Qualcomm, CATT, FGI, Fujitsu, LG * Per TDRA codepoint for scheduled/activated PDSCH/PUSCH: Apple * Per DCI with UL grant for the scheduled/activated PUSCH: vivo (reinterpret the SRS resource set indicator), Qualcomm, MTK, Xiaomi (reinterpret the SRS resource set indicator), Fujitsu, LG * Per dedicated PUCCH resource: Ericsson, ZTE, CATT (MAC-CE update), Nokia, MTK, Apple, Docomo, Xiaomi, LG * Per [P/SP] CSI-RS resource or resource set: Ericsson, ZTE, vivo, MTK, Apple (set), Docomo, Fraunhofer, Xiaomi, LG * Per [P/SP] SRS resource set: Ericsson, OPPO, Nokia, ZTE, vivo, MTK, Apple (set) , Docomo, Fraunhofer, Xiaomi, LG * Per DCI with CSI request for the triggered AP CSI-RS: vivo * Per DCI with SRS request for the triggered AP SRS: vivo * Per Type-1 CG configuration: Nokia, Fraunhofer, Xiaomi | For PDCCH, Proposal 1.E is recommended accordingly  For PDSCH, Proposal 1.F is recommended accordingly  If two indicated TCI states are mapped to a channel, how to map the indicated TCI states to each of repetition occasions (or CDM groups) of the channel can be further discussed. |
| 1.12 | Applying/mapping the indicated TCI states to channels/signals for M-DCI based MTRP | Unified schemes for both S-DCI and M-DCI to apply/map the indicated TCI states to channel(s)/signal(s)   * Support: Ericsson, Docomo * Concern: Nokia, Huawei   The indicated TCI state(s) respective to one of *CORESETPoolIndex* values applies to:   * PDCCH on the CORESET(s) configured/associated with the *CORESETPoolIndex* value (as in Rel-17): ZTE, Qualcomm, Nokia, vivo, Samsung, MTK, LGE, Xiaomi, Apple, Docomo, Fraunhofer, OPPO, Fujitsu, TransHold, Intel * PDSCH/PUSCH scheduled/activated by the DCI associated with the *CORESETPoolIndex* value: ZTE, Xiaomi, MTK, vivo, Qualcomm, Samsung, Apple, Fraunhofer, Fujitsu, TransHold, Intel * PUCCH with HARQ-ACK corresponding to the DCI associated with the *CORESETPoolIndex* value: Nokia, vivo, Qualcomm, Apple, Fraunhofer, TransHold * AP CSI-RS triggered by the DCI associated with the *CORESETPoolIndex* value: ZTE, Xiaomi, Nokia, ZTE, vivo, Qualcomm, Apple, OPPO * AP SRS triggered by the DCI associated with the *CORESETPoolIndex* value: ZTE, Xiaomi, Nokia, ZTE, vivo, Qualcomm, Apple   For channels/signals that don't have explicit/implicit association with a *CORESETPoolIndex* value:   * Introduce an indicator (reuse *CORESETPoolIndex* or a new one) to indicate which indicated TCI state(s) (or which TRP(s)) is associated with the corresponding channel/signal: Nokia, Apple, vivo, Fraunhofer, ZTE, MTK, Xiaomi, Docomo, FGI, LG | For PDCCH, Proposal 1.G is recommended accordingly  Whether an explicit association between indicated TCI state(s) and an *CORESETPoolIndex* value is needed may depend on the result of sub-issue 1.7, thus can be further studied |

## Proposal 1.B-2: On unified TCI framework extension [at least] for MTRP operation:

* + Support [at least] up to 2 indicated joint TCI states in a CC/BWP for joint DL/UL TCI update
  + Support [at least] up to 2 indicated DL TCI states and up to 2 indicated UL TCI states in a CC/BWP for separate DL/UL TCI update
* The indicated joint/DL/UL TCI states are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
  + Note: The term “indicated joint/DL/UL TCI states” refers to a set of joint/DL/UL TCI states that UE needs to maintain and may apply simultaneously to the channels/signals that share the “indicated joint/DL/UL TCI states” in a CC/BWP
  + Note: It does not imply that indicated joint TCI state(s) and indicated DL/UL TCI state(s) can be supported in a same CC/BWP
  + FFS: Whether indicated joint TCI state(s) and indicated DL and/or UL TCI state(s) can be supported in a same CC/BWP
  + FFS: How to determine the exact number of indicated joint/DL/UL TCI states that need to be maintained in a CC/BWP, e.g., based on the indicated TCI codepoint, TCI state activation, or RRC configuration
  + FFS: The maximum number of indicated joint/DL/UL TCI states per TRP
  + FFS: Details of update and activation for the indicated joint/DL/UL TCI states for S-DCI based MTRP
  + FFS: Details of update and activation for the indicated joint/DL/UL TCI states for M-DCI based MTRP
  + FFS: How to map/apply one or multiple indicated joint/DL/UL TCI states to a target channel(s)/signal(s)
  + FFS: Extension of unified TCI framework to the case of CJT with support of more than 2 indicated joint/DL/UL TCI state(s)

## Proposal 1.D-4: On unified TCI framework extension for M-DCI based MTRP, consider the following alternatives for TCI state update and investigate the possibility to have one solution for S-DCI and M-DCI based M-TRP

* Alt1: 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
* Alt2: 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
* Alt3: Use the existing TCI field in 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 *CORESETPoolInde* value is indicated by DCI

Note: This doesn't imply any prioritization for S-DCI or M-DCI, and both S-DCI and M-DCI should be treated equally when study/discuss

## Proposal 1.E-1: On unified TCI framework extension for singe-DCI based MTRP, consider at least the following alternatives to map/associate a joint/DL TCI state to PDCCH reception(s) ~~on a CORESET that shares the indicated joint/DL TCI state(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 if support, dynamic switching between S-TRP and M-TRP PDCCH. It is not precluded to adopt one single alternative or multiple alternatives to support these cases.

## Proposal 1.F: On unified TCI framework extension for S-DCI based MTRP, if two joint/DL TCI states are indicated, consider at least the following alternatives to select one or two joint/DL TCI state(s) from the two indicated joint/DL TCI states for PDSCH reception(s):

* Atl1: Introduce a field (other than the existing TCI field) in a scheduling/activation DCI to indicate the selection
* Alt2: Use the TDRA in a scheduling/activation DCI to indicate the selection
* Alt3: Use the existing TCI field to indicate the selection
* Note: Other alternatives are not precluded

Study, when two joint/DL TCI states are selected for the corresponding PDSCH reception, the mapping between the two selected joint/DL TCI states and PDSCH Tx occasions, non-overlapping FDRAs, and CDM groups, and it is not precluded to reuse the Rel-16 mapping rule

## Proposal 1.G: On unified TCI framework extension for M-DCI based MTRP, consider at least the following alternatives to map/associate a joint/DL TCI state to PDCCH reception(s) on a CORESET that shares the indicated joint/DL TCI state(s):

* Alt1: For a CORESET configured/associated with one of *CORESETPoolIndex* values, the UE should apply the indicated joint/DL TCI state corresponding to the *CORESETPoolIndex* value to PDCCH reception(s) on the CORESET
* Alt2: Use RRC configuration other than *CORESETPoolIndex* to inform the mapping/association between a configured or indicated joint/DL TCI state and a CORESET or a CORESET group
* Alt3: Use RRC configuration other than *CORESETPoolIndex* to inform the mapping/association between a configured or indicated joint/DL TCI state and a search space set

## Proposal 1.H: On unified TCI framework extension, study the followings for RRC-configured TCI state list(s)

* Whether to introduce TCI state list(s) per each TRP
* Whether to increase the max number of configured TCI states in the joint/DL TCI state list and the UL TCI state list

Table 2 Additional inputs for Issue 1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | 1. **Please check Proposal 1.F and 1.G** 2. **Please check new Proposal 1.H** |
| QC | For Proposal 1.F, is the intention to dynamically down select one from the two indicated TCIs for a particular PDSCH, i.e. NW indicates two sticky TCIs but wants either one or both of them to be used for a particular PDSCH, e.g. the PDSCH scheduled by the same TCI updating TCI? From the summary table above, it seems the case. If so, may I suggest the following wording? This is to emphasize:   * Such dynamic selection is only needed when 2 sticky TCIs are indicated; * The selection of 1 or 2 TCIs for a particular PDSCH is from the 2 indicated sticky TCIs; * The TCI down selection is signaled in the scheduling or activation DCI  Proposal 1.F: On unified TCI framework extension for S-DCI based MTRP, if two joint/DL TCI states are indicated, consider at least the following alternatives to dynamically select ~~indicate the~~ ~~mapping/association between~~ one or two TCI states ~~indicated joint/DL TCI states~~ ~~and~~ for PDSCH reception(s) from the two indicated joint/DL TCI states:  * Atl1: Introduce a field (other than the existing TCI field) in a scheduling/activation DCI to indicate the ~~mapping/association~~ one or two selected TCI states * Alt2: Use the TDRA in a scheduling/activation DCI to indicate the ~~mapping/association~~ one or two selected TCI states * Alt3: Use the existing TCI field to indicate the ~~mapping/association~~ one or two selected TCI states * Note: Other alternatives are not precluded   Study, the mapping between the two selected ~~indicated~~ joint/DL TCI states and PDSCH Tx occasions, non-overlapping FDRAs, and CDM groups when two indicated joint/DL TCI states are ~~mapped/associated to~~ selected for the corresponding PDSCH reception, and it is not precluded to reuse the Rel-16 mapping rule  **[Mod] Adopt. However, since other alternatives, non-dynamic selection is still possible. It is better to remove “dynamic” at this stage, and it is implied by the signaling mechanism.**  For 1.G, support Alt1. Seems no need to introduce new RRC if we have CORESETPoolIndex  For 1.H, fine to study |
| Lenovo | Proposal 1.F: Support. It is good to discuss multiple proposals at this stage.  Proposal 1.G: For M-DCI based MTRP, when more than one 1 joint/DL TCI state is indicated in a DCI, will there be any CORESETPoolIndex configured for the CORESETs? This needs to be clarified for Alt 2 and 3.  Proposal 1.H: The maximal number of configured TCI states may be increased for MTRP, but how to configure the TCI state lists can be left for gNB implementation. |
| ZTE | Proposal 1.F: Support QC’s update. But, we are not convinced why we need to study the following. Why we can not use existing rule?  **[Mod] If no issue, reusing existing one is natural, but we can further study/check.**  Study the mapping between the indicated joint/DL TCI states and PDSCH Tx occasions, non-overlapping FDRAs, and CDM groups when two indicated joint/DL TCI states are mapped/associated to the corresponding PDSCH reception, and it is not precluded to reuse the Rel-16 mapping rule  Proposal 1.G. Support Alt-1, but for Alt-2 and Alt-3, we have the similar concerns as QC and Lenovo, why we still need a new one herein.  Proposal 1.H. Support. In our views, the mapping between TCI state and TRPs should be static, and we do not see the necessity of dynamically updating this mapping. If our understanding is correct, TRP-specific TCI state pool should be straightforward. |
| Mod V1 | **Proposal 1.B-2, 1.D-2, 1.D-3, 1.D-4, 1.E-2 are added back for potential GTW discussion** |
| vivo | Proposal 1.B-2: If “[at least] is added to the 1st and 2nd bullet, it should be also added to the 1st FFS.  * + FFS: Whether [at least] 1 indicated joint TCI state and [at least] 1 indicated DL and/or UL TCI state(s) can be supported in a same CC/BWP  Besides, can we explain the meaning of [at least] in the last bullet as  * + FFS: Extension of unified TCI framework to the case of CJT with support of more than 2 indicated joint/DL/UL TCI state(s) which is implied by [at least]   **[Mod] Revised**  **Proposal 1.D series:**  Proposal 1.D-2 and Proposal 1.D-4 are both for M-DCI based MTRP, are we going to agree one of them? In our mind, as CORESETPoolIndex only configured for M-DCI based MTRP, proposal 1.D-2 or Proposal 1.D-4 cannot be applicable to S-DCI based MTRP.  **[Mod] Both Proposal 1.D-2 and Proposal 1.D-3 have proponents. Proposal 1.D-4 is a compromise one.**  **Proposal 1.E-2:** We’d like to agree on S-DCI based MTRP.  **Proposal 1.F:** Support latest version.  **Proposal 1.G:** Support.  **Proposal 1.H:** Support. |
| Huawei, HiSilicon | Proposal 1.B-2: We do have a strong concern on the limitation of number of TCI states even with “at least up to 2”. In the inter-site CJT deployment, each TRP/cell has its own TRS and TCI state, so 4 TCI states are required. If only 1 or 2 TCI states indication is supported, we are not sure how inter-site CJT can work. So, we still have to insist that the number of indicated TCI states should be up to 4. Also, we don’t think extension of unified TCI framework to the case of CJT should be only an FFS. We propose the following modification to the latest version of Proposal 1.B-2: Proposal 1.B-2 (modified): On unified TCI framework extension [at least] for MTRP operation:  * + Support ~~[at least]~~ up to ~~2~~ 4 indicated joint TCI states in a CC/BWP for joint DL/UL TCI update   + Support ~~[at least]~~ up to ~~2~~ 4 indicated DL TCI states and up to ~~2~~ 4 indicated UL TCI states in a CC/BWP for separate DL/UL TCI update * The indicated joint/DL/UL TCI states are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation   + Note: The term “indicated joint/DL/UL TCI states” refers to a set of joint/DL/UL TCI states that UE needs to maintain and may apply simultaneously to the channels/signals that share the “indicated joint/DL/UL TCI states” in a CC/BWP   + Note: It does not imply that indicated joint TCI state(s) and indicated DL/UL TCI state(s) can be supported in a same CC/BWP   + FFS: Whether 1 indicated joint TCI state and 1 indicated DL and/or UL TCI state(s) can be supported in a same CC/BWP   + FFS: How to determine the exact number of indicated joint/DL/UL TCI states that need to be maintained in a CC/BWP, e.g., based on the indicated TCI codepoint, TCI state activation, or RRC configuration   + FFS: The maximum number of indicated joint/DL/UL TCI states per TRP   + FFS: Details of update and activation for the indicated joint/DL/UL TCI states for S-DCI based MTRP   + FFS: Details of update and activation for the indicated joint/DL/UL TCI states for M-DCI based MTRP   + FFS: How to map/apply one or multiple indicated joint/DL/UL TCI states to a target channel(s)/signal(s)   + ~~FFS: Extension of unified TCI framework to the case of CJT with support of more than 2 indicated joint/DL/UL TCI state(s)~~  Proposal 1.D-2: Support **Proposal 1.D-3:** We are not ready to support this proposal and prefer 1.D-2 that considers the same logic as in legacy releases. We think that Proposal 1.D-3 entails a lot of specification work since is not aligned with Rel-16, Rel-17 supported mechanism.  **Proposal 1.D-4:** We think 1.D-2 is the better and more straightforward option.  **Proposal 1.E-2:**  We have two comments:   1. We don’t think adding “investigate the possibility to have one solution for S-DCI and M-DCI based M-TRP” to the main bullet is needed. We think that such a unified solution entails a lot of specification work since is not aligned with Rel-16, Rel-17 supported mechanism. However, if adding this text has a strong support, we would be willing to accept it; 2. We think that “dynamic switching between S-TRP and M-TRP PDCCH” is an important issue that needs to be considered. We don’t need to put “if supported” behind it. As an example, consider the case of dynamic switching between m-TRP SFN PDCCH and s-TRP PDCCH: If UE is in m-TRP regime with two TCI states, and the regime changes to s-TRP, there may be an ambiguity if gNB sends a new DCI with single indicated TCI state as UE may misinterpret it as updating only one of the two indicated TCI states (and not changing the regime from m-TRP to s-TRP).   **[Mod] Is dynamic switching between S-TRP and M-TRP PDCCH supported for all legacy MTRP schemes?**  **If not, are you going to introduce new MTRP scheme(s)?**  Given above two comments, we suggest the following changes: Proposal 1.E-2 (modified): On unified TCI framework extension for singe-DCI based MTRP, consider at least the following alternatives to map/associate a joint/DL TCI state to PDCCH reception(s) ~~on a CORESET that shares the indicated joint/DL TCI state(s) and investigate the possibility to have one solution for S-DCI and M-DCI based M-~~TRP  * 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 ~~if support,~~ supporting dynamic switching between S-TRP and M-TRP PDCCH. It is not precluded to adopt one single alternative or multiple alternatives to support these cases.  **Proposal 1.F:** We are not sure how Alt.2 can work. Can proponents please explain?  **[Mod] It is listed for study**  **Proposal 1.G:** We are not sure about the motivation of Alt2 or Alt3. Why they may work better than Alt1 which is the legacy mechanism? Can proponents please explain?  **[Mod] It is listed for study**  **Proposal 1.H:** Support |
| Fujitsu | Proposal 1.B-2: Support.  Proposal 1.D: We are fine with either Proposal 1.D-2, 1.D-3 or Proposal 1.D-4.  Proposal 1.E-2: Support.  Proposal 1.F: We are fine with this proposal which seems to be general enough. In our understanding, the intention seems to discuss whether to support indicating one of the two TCI states during the application time of these two TCI states. The answers and solutions can be covered by the three alternatives.  Proposal 1.G: Support. It can be seen as a further detail of previous Proposal 1.D. Proposal 1.H: We are fine with the proposal. |
| Mod V2 | **Remove 1.D-2 and 1.D-3. Let’s check whether 1.D-4 is acceptable by the group** |
| Xiaomi | Proposal 1.B-2, support. We prefer to consider non-CJT first.  For Proposal 1.D-2, 1.D-3 and 1.D-4, we are fine with either 1.D-2 or 1.D-4.  Proposal 1.E-1, we prefer to keep ‘on a CORESET……’ since it is the target use case.  Proposal 1.F: support  Proposal 1.G: support  Proposal 1.H: for the two sub-bullet, we think at most one of them will be supported if necessary. |
| LG | Fine with the updated proposals above and one editorial comment on proposal 1.F (blue text) as:Proposal 1.F: On unified TCI framework extension for S-DCI based MTRP, if two joint/DL TCI states are indicated, consider at least the following alternatives to select one or two joint/DL TCI state(s) from the two indicated joint/DL TCI states for PDSCH reception(s): **[Mod] Thanks** |
| OPPO | **Proposal 1.B-2:** We are fine to add [at least] up to 2 indicated joint/DL/UL TCI states.  If the wording “up to 2” sounds restrictive, i.e. putting a cap on the maximum number, perhaps we may just say “Support 1 or 2 indicated Joint/DL/UL TCI state(s)”.  But given current discussion on CJT operation @FR1, we don’t think it’s mature enough to support up to 4 indicated Joint/DL/UL TCI states, thus should be an FFS.  **Proposal 1.D-4:** We support to consider M-DCI based MTRP for unified TCI state extension.  But the following crossed red text implies to reuse the solution of S-DCI (not determined yet) for M-DCI, and functional-wise it should be listed as another alternative along with the other three alternatives to address the same issue as in previous version provided by FL. Or this general principle of striving for the same solution for both M-DCI and S-DCI can be another independent proposal. Moreover, if we put such “investigation” only for M-DCI MTRP here and leave it blank for e.g. Proposal 1.E-1, it seems against the spirit in the note down below to have no prioritization for S-DCI or M-DCI.  One particular question for Alt1. Is it necessary to “study the association between joint/DL/UL TCI state(s) and the CORESETPoolIndex value”? Otherwise, it seems not clear to us on how to associate an indicated TCI state to the CORESETPoolIndex. Thank you. Proposal 1.D-4: On unified TCI framework extension for M-DCI based MTRP, consider the following alternatives for TCI state update ~~and investigate the possibility to have one solution for S-DCI and M-DCI based M-TRP~~  * Alt1: 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   + Study the association between joint/DL/UL TCI state(s) and the CORESETPoolIndex value * Alt2: 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 joint/DL/UL TCI state(s) and a *CORESETPoolIndex* value * Alt3: Use the existing TCI field in 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 *CORESETPoolInde* value is indicated by DCI   Note: This doesn't imply any prioritization for S-DCI or M-DCI, and both S-DCI ~~or~~ and M-DCI should be treated equally when study/discuss  **Proposal 1.E-1:** support.  **Proposal 1.F:** we are in general fine.  But the format of alternatives could be re-considered, for instance reusing Rel.16 TCI state(s) to PDSCH mapping rule can be listed as an alternative. If not, it appears that the newly listed schemes, from Alt1 to Alt3 have been prioritized over other approaches.  **Proposal 1.G:** it seems a variant of Proposal 1.D-4 and we tend to think it can be discussed later than Proposal 1.D-4.  **Proposal 1.H:** not support.  First, we don’t think it is necessary to configure TCI state pool on a per TRP basis, when concrete benefits are not unveiled yet. That’s against legacy RRC signaling design in which one common TCI state pool per BWP can be shared by two TRPs.  Secondly, it seems too early to discuss the maximum number of Joint/DL TCI states and UL TCI states. By default, it may inherit the maximum number of Rel.17 unified TCI states. |
| Spreadtrum | Proposal 1.B-2: support  Proposal 1.D-4: We prefer to discuss m-DCI based m-TRP scheme in Proposal 1.D-4, the investigation of the solution applied to both S-DCI and m-DCI can be proposed as an independent proposal.    Proposal 1.E-1: support  Proposal 1.F: support  Proposal 1.H: support |
| Fraunhofer IIS/HHI | **Proposal 1.B-2:** Agree in principle. Our support is primarily for S-DCI and M-DCI based MTRP operation with up to 2 indicated TCI-states. We are OK to study the CJT use-case further (as included in the FFS). However, in our opinion, the proposal could be framed better to capture this. The proposal can state ‘Support up to X indicated xxx TCI-states’ followed by ‘At least X = 2 is supported. Further study X>2 for CJT use-case.’  **Proposal 1.D-4:** Ok in general. The sub-bullet in Alt-2 seems to call for association for any TCI-state with a CORESET pool index value. In our opinion, restricting to just the indicated TCI-states is enough.     * Study the association between the indicated joint/DL/UL TCI state(s) and a *CORESETPoolIndex* value   **[Mod] Adopted**  **Proposal 1.E-1, 1.F, 1.G:** Support  **Proposal 1.H:** Not clear about the advantages of different TCI pools for different TRPs, but OK to leave it for study since it’s just the first meeting. |
| CMCC | Proposal 1.B-2/1.D-4/1.E-1/1.F/1.G: Support.  Proposal 1.H: We think there is no need to introduce TCI state list(s) per each TRP, as only one TCI state pool is used in R16 M-TRP. |
| CEWiT | Proposal 1.B-2: Support  Proposal 1.D-4: Support  Proposal 1.E-1: Support  Proposal 1.F: Support  Proposal 1.G: Support  Proposal 1.H: Fine to study |
| Transsion | Proposal 1.B-2: Support. For the second sub-bullet, we are fine to study all the valid combinations(e.g. DL+UL TCI state).  Proposal 1.D-4: Support.  Proposal 1.E-1: Support  Proposal 1.F: Support in general.  Share the same view as OPPO that reusing Rel.16 TCI state(s) to PDSCH mapping rule can be listed as an alternative.  Proposal 1.G: Support Alt1. Using the existing RRC parameter (e.g. CORESETPoolIndex) may has less spec impact.  Proposal 1.H: Fine to study the second sub-bullet. |
| Ericsson | Proposal 1.B-2: Support  Proposal 1.D-4: Don’t support. We would be OK if the alternatives are removed. With the alternatives, this proposal steers towards a separate solution for mDCI, and we think we should not invest time in options that exclude a unified solution.  Proposal 1.E-1: Similar to Proposal 1.D-4, we think the alternatives could be removed.  Proposal 1.F: Don’t support. When we designed the R15 TCI/spatial framework, we considered the channels independently. This led to fundamentally different solutions for the different channels: PDSCH, PDCCH, PUSCH, PUCCH, CSI-RS, SRS. In Rel-17, we managed to unify all these channels. The methodology was to start from the assumption that all channels used the same TCI state – this was in the very first agreement. If we in R18 now start to discuss each channel independently in parallel, we will most likely end up in the R15 situation again, with different solutions for different channels. We think we need to discuss more than one channel at a time and agree on a solution with common characteristics. Or alternatively, we could make a working assumption for one channel, and adopt that solution for other channels. I realize that this is not easy.  Proposal 1.G: Don’t support as is. OK if alternatives are removed and changed to “study”. We would also like to see “investigate the possibility to have one solution for S-DCI and M-DCI based M-TRP” also for this proposal.  Proposal 1.H: Support. |
| InterDigital | Proposal 1.B-2: Support  Proposal 1.D-4: Support. We prefer to keep “investigate the possibility to have one solution for S-DCI and M-DCI based M-TRP” for study.  Proposal 1.E-1: Support  Proposal 1.F: Fine to study. But, this kind of “two-step” dynamic selection is not beneficial as eventually the final selector consumes DCI overhead. It is simpler and better to select one or two TCI states directly from a codepoint of the TCI field, similar to what we have for existing S-DCI for MTRP. We can consider to increase bitwidth of the field (e.g., extension to 4-bit TCI field), which eventually achieves the same thing.  Proposal 1.G: Fine to study.  Proposal 1.H: Similar view as CMCC. But, fine to study the second sub-bullet. |

# Issue 2 – UL Power Control for UL MTRP

Void

# Issue 3 – Beam reporting and beam failure recovery

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

Table 5 Summary for Issue 3

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 3.1 | Enhance/extend group-based reporting to support simultaneous UL transmission | Support: Qualcomm, Samsung, vivo, MTK, Nokia, Xiaomi, ZTE, Huawei  Concern: Apple, Ericsson, OPPO | This issue can be discussed once any Rel-18 MTRP scheme for simultaneous UL transmission is agreed |
| 3.2 | Enhance/extend Rel-17 UE capability index reporting to support simultaneous UL transmission | Support: Samsung, Nokia, CATT, LGE, MTK, AT&T, QC, Apple, Docomo, Lenovo, Xiaomi, OPPO, ZTE, Huawei  Concern: Ericsson | This issue can be discussed once any Rel-18 MTRP scheme for simultaneous UL transmission is agreed |
| 3.3 | Enhancement to TRP-specific BFR under unified TCI framework | Support: InterDigital, vivo, Samsung, Apple, Qualcomm, Docomo, Nokia, NEC, Lenovo, Xiaomi, ZTE, Spreadtrum, TransHold, Huawei  Concern: Ericsson |  |

## Proposal 3.A: If STxMP is supported, study the following:

* Enhancement to group-based reporting (including Rel-17 enhanced group-based reporting) to support STxMP
* Enhancement to Rel-17 UE capability index reporting to support STxMP

Support: Transsion, Xiaomi, ZTE, OPPO, Samsung, Nokia, CATT, IDG, Lenovo, QC, CMCC, vivo, LG, Docomo, MTK

Concern: Huawei, Ericsson

## Proposal 3.B: Study potential enhancement to TRP-specific BFR under unified TCI framework

Support: Transsion, Xiaomi, ZTE, OPPO, Samsung, Nokia, CATT, IDG, Lenovo, QC, CMCC, vivo, LG, Docomo, MTK

Concern: Ericsson

Table 6 Additional inputs for Issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your views on Proposal 3.A and 3.B, if any** |
| QC | For 3.A, support  For 3.B, support |
| Lenovo | Proposal 3A: Support  Proposal 3B: Support |
| ZTE | Support both. If our understanding is correct, above is just for study, right? Let’s do it easily. ^\_^ |
| vivo | Support both. |
| Huawei, HiSilicon | **Proposal 3.A:**  We still have a serious concern. The proposal is too detailed and we don’t see any reason to support it at this stage. STxMP is planned to be evaluated and companies are just trying to finalize EVM. If it turns out that STxMP should be supported based on the evaluations campaign, we can then move forward with to study/specify these details. Spending online/offline time resources during the meetings on these detail issues when STxMP is not even supported yet seems unwarranted.  Please also note that companies don’t need an agreement to study this issue in their t-docs.  **Proposal 3.B:** Support |
| Fujitsu | Proposal 3A: Support  Proposal 3B: Support |
| LG | Support both proposals. |
| OPPO | Support both Proposal 3.A and 3.B. |
| Spreadtrum | Proposal 3B: Support |
| Fraunhofer IIS/HHI | Fine with both proposals. |
| CMCC | Support both. |
| Transsion | Support both Proposal 3.A and 3.B. |
| Ericsson | Proposal 3.A: OK to study. But in light of the recent guidance from the chair, we still feel this would fit better in AI 9.1.4.1.  Proposal 3.B: Don’t support at this point in time. This has low prio. |
| InterDigital | Supoort both Proposal 3.A and 3.B. |

# Other potential issues

Table 7 Inputs for other potential issues

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your view if there is any open issue that need to be addressed with high priority but is not captured above** |
|  |  |

# Appendix A: Agreements before/in RAN1#109-e

**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, 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

# Appendix B: Proposal Pool (PP)

## Proposal 1.B-2: On unified TCI framework extension [at least] for MTRP operation

* + Support up to M1 indicated joint TCI states in a CC/BWP for joint DL/UL TCI update
  + Support up to M2 indicated DL TCI states and up to N2 indicated UL TCI states in a CC/BWP for separate DL/UL TCI update
  + Select one of the following alternatives by RAN1#110:
    - Alt1: M1 = 2, M2 = 2, N2 = 2
    - Alt2: M1 = 4, M2 = 4, N2 = 4
    - Alt3: M1 = 4, M2 = 4, N2 = 4 only for CJT. Otherwise, M1 = 2, M2 = 2, N2 = 2.
* The indicated joint/DL/UL TCI states are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
  + Note: The term “indicated joint/DL/UL TCI states” refers to a set of joint/DL/UL TCI states that UE needs to maintain and may apply simultaneously to the channels/signals that share the “indicated joint/DL/UL TCI states” in a CC/BWP
  + Note: It does not imply that indicated joint TCI state(s) and indicated DL/UL TCI state(s) can be supported in a same CC/BWP
  + FFS: Whether indicated joint TCI state(s) and indicated DL and/or UL TCI state(s) can be supported in a same CC/BWP
  + FFS: How to determine the exact number of indicated joint/DL/UL TCI states that need to be maintained in a CC/BWP, e.g., based on the indicated TCI codepoint, TCI state activation, or RRC configuration
  + FFS: The maximum number of indicated joint/DL/UL TCI states per TRP
  + FFS: Details of update and activation for the indicated joint/DL/UL TCI states for S-DCI based MTRP
  + FFS: Details of update and activation for the indicated joint/DL/UL TCI states for M-DCI based MTRP
  + FFS: How to map/apply one or multiple indicated joint/DL/UL TCI states to a target channel(s)/signal(s)

## Proposal 1.D-2: On unified TCI framework extension for M-DCI based MTRP, consider the following alternatives for TCI state update and study whether or not the single-DCI MTRP solution is applicable also to multi-DCI MTRP

* Alt1: 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
* Alt2: 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 joint/DL/UL TCI state(s) and a *CORESETPoolIndex* value
* Alt3: Use the existing TCI field in 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

Note: This doesn't imply any prioritization for S-DCI or M-DCI, and both S-DCI and M-DCI should be treated equally when study/discuss

## Proposal 1.D-3: Until RAN1#110, investigate the possibility to have one solution for sDCI and mDCI mTRP

# References

1. RP-213598 New WID: MIMO Evolution for Downlink and Uplink Samsung
2. R1-2203887 Views on unified TCI extension focusing on m-TRP xiaomi
3. R1-2203793 Unified TCI framework extension for multi-TRP Sony
4. R1-2203723 Consideration on Unified TCI framework for multi-TRP OPPO
5. R1-2203953 Unified TCI framework extension for multi-TRP Sony
6. R1-2204033 Unified TCI framework extension for multi-TRP Ericsson
7. R1-2204229 Views on unified TCI framework extension for multi-TRP Apple
8. R1-2204367 Discussion on unified TCI framework extension for multi-TRP NTT DOCOMO, INC
9. R1-2204141 Unified TCI framework extension for multi-TRP/panel LG Electronics
10. R1-2204162 Discussion of unified TCI framework for multi-TRP Lenovo
11. R1-2203681 Discussion on unified TCI framework extension for multi-TRP NEC
12. R1-2203541 Views on unified TCI framework extension for multi-TRP vivo
13. R1-2203378 On Extension of Unified TCI Framework InterDigital, Inc.
14. R1-2203441 On unified TCI framework extension for multi-TRP operation CATT
15. R1-2203149 Discussion on unified TCI framework extension for multi-TRP Huawei, HiSilicon
16. R1-2203061 Unified TCI framework extension for multi-TRP FUTUREWEI
17. R1-2203320 Discussion on Unified TCI framework extension for multi-TRP Spreadtrum Communications
18. R1-2203174 Discussion on Unified TCI framework extension for multi-TRP CEWiT
19. R1-2203263 Enhancements on unified TCI framework extension for multi-TRP ZTE
20. R1-2205071 Discussion on unified TCI framework extension for multi-TRP Asia Pacific Telecom co. Ltd
21. R1-2205074 Considerations on unified TCI for mTRP Fujitsu Limited
22. R1-2204785 On Unified TCI framework for mTRP Intel Corporation
23. R1-2204678 Multi-TRP enhancements for the unified TCI framework Fraunhofer IIS, Fraunhofer HHI
24. R1-2204857 Unified TCI framework extension for multi-TRP AT&T
25. R1-2205014 Extension of unified TCI framework for mTRP Qualcomm Incorporated
26. R1-2204584 Enhancement on unified TCI framework for multi-TRP Transsion Holdings
27. R1-2204538 Unified TCI framework extension for multi-TRP Nokia, Nokia Shanghai Bell
28. R1-2204684 Unified TCI framework extension for multi-TRP MediaTek Inc.
29. R1-2204287 Discussion on unified TCI framework extension for multi-TRP CMCC
30. R1-2204506 Unified TCI framework extension for multi-TRP Sharp
31. R1-2204440 Discussion on unified TCI framework extension for multi-TRP ITRI