**3GPP TSG RAN WG1 #109-e R1-2205225**

**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 1)

**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 1 is intended to prepare the group for the GTW session on Thursday May 12th 03:00 UTC. Please share your inputs by Wednesday May 11th 23:59 UTC.**

# 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** |
| 1.1 | All the MTRP schemes specified in Rel-16/17 are considered/applicable by extension of unified TCI framework, including the followings:   * Rel-16 M-DCI based MTRP * Rel-16 S-DCI based SDM scheme for PDSCH * Rel-16 S-DCI based PDSCH repetition schemes with FDM and TDM * Rel-17 S-DCI based PUSCH repetition scheme with TDM * Rel-17 S-DCI based PDCCH repetition scheme * Rel-17 S-DCI based PUCCH repetition scheme with TDM * Rel-17 PDCCH-SFN and PDSCH-SFN | Support: Ericsson, Samsung, Docomo, vivo, Qualcomm, ZTE, MTK, CATT, NEC, Lenovo, Intel, Huawei, Nokia, InterDigital, FGI  Concern: Apple (Clarification for R16 mDCI, does it include PDSCH only or not? ) | Given the majority view on this issue, Proposal 1.A is recommended accordingly.  Rel-18 MTRP scheme(s) for simultaneous UL transmission can be further discussed once it is agreed |
| 1.2 | Rel-17 inter-cell MTRP is considered/applicable by extension of unified TCI framework | Support: Docomo, MTK, CATT, NEC, Lenovo, Ericsson, Huawei, Apple, Nokia, InterDigital, FGI  Concern: | Rel-17 inter-cell MTRP is also captured in Proposal 1.A since it is also one of Rel-17 MTRP schemes, even it was not mentioned by many contributions. |
| 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   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  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  Concern: Apple (no use case) |  |
| **Note: On definition of “unified TCI” in this table, for joint DL/UL TCI update, one “unified TCI” comprises one indicated joint TCI state. For separate DL/UL TCI update, one “unified TCI” comprises one indicated DL TCI state and/or one indicated UL TCI state.** | | | |
| 1.6 | TCI state update for S-DCI based MTRP | Use existing (single) TCI field in DCI to update all **unified TCIs**:   * 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 * Concern:   More than one TCI fields in DCI w/o DLA and each TCI field can update one respective **unified TCI**:   * Support: Samsung, OPPO, FGI * Concern: Apple (DCI overhead) | Given the majority view on this issue, Proposal 1.C is recommended accordingly.  How to activate TCI states for the multiple unified TCIs 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 **unified TCI** respective to the *CORESETPoolIndex* value   * Support: Samsung, Nokia, Docomo, Qualcomm, Intel, ZTE, vivo, MTK, Xiaomi. LGE, Fraunhofer, FGI * Concern: Apple (does it support cross-TRP beam indication?), Ericsson   Alt2: Use existing (single) TCI field DCI associated with one of *CORESETPoolIndex* values to update the **unified TCIs** respective to both *CORESETPoolIndex* values   * Support: Apple, Xiaomi * Concern: Docomo (not good in non-ideal backhaul), Ericsson, InterDigital | How to activate TCI states for the multiple unified TCIs can be discussed after the update scheme is sufficiently mature |
| 1.8 | DCI format for updating the **unified TCIs** | 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, Docomo, Nokia, Ericsson * 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 * Concern: Docomo, Ericsson |  |
| 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 * 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 |  |
| 1.10 | Introduction of TRP-ID associated with or included in each TCI state | Support: CMCC, Spreadtrum  Concern: Ericsson, MTK, Apple, Docomo, Nokia, CATT |  |
| 1.11 | Applying/mapping the **unified TCIs** to target channel/signals for S-DCI based MTRP | To inform to the UE at least which **unified TCI(s)** (or which TRP(s)) is mapped to the corresponding channel/signal, an indicator is introduced:   * Per CORESET or per search space set: Ericsson, Xiaomi, ZTE, vivo, CATT, Nokia, MTK, Qualcomm, Samsung, Apple (CORESET), Docomo, FGI * Per DCI with DL assignment for the scheduled/activated PDSCH: ZTE, vivo, MTK, Qualcomm, CATT, FGI * 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) * Per dedicated PUCCH resource: Ericsson, ZTE, CATT (MAC-CE update), Nokia, MTK, Apple, Docomo, Xiaomi * Per [P/SP] CSI-RS resource or resource set: Ericsson, ZTE, vivo, MTK, Apple (set), Docomo, Fraunhofer, Xiaomi * Per [P/SP] SRS resource set: Ericsson, OPPO, Nokia, ZTE, vivo, MTK, Apple (set) , Docomo, Fraunhofer, Xiaomi * 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 | If more than one unified TCIs are mapped to a target channel, how to map the unified TCIs to each of repetition occasions (or CDM groups) of the target channel can be further discussed. |
| 1.12 | Applying/mapping the **unified TCIs** to target channels/signals for M-DCI based MTRP | Unified schemes for both S-DCI and M-DCI to apply/map the **unified TCIs** to target channels/signals   * Support: Ericsson, Docomo * Concern: Nokia, Huawei   The **unified TCI** 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 * PDSCH/PUSCH scheduled/activated by the DCI associated with the *CORESETPoolIndex* value: ZTE, Xiaomi, MTK, vivo, Qualcomm, Samsung, Apple, Fraunhofer * PUCCH with HARQ-ACK corresponding to the DCI associated with the *CORESETPoolIndex* value: Nokia, vivo, Qualcomm, Apple, Fraunhofer * AP CSI-RS triggered by the DCI associated with the *CORESETPoolIndex* value: ZTE, Xiaomi, Nokia, ZTE, vivo, Qualcomm, Apple * 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 at least which **unified TCI** (or which TRP) is associated with the corresponding channel/signal: Nokia, Apple, vivo, Fraunhofer, ZTE, MTK, Xiaomi, Docomo, FGI | Whether an explicit association between a unified TCI and an *CORESETPoolIndex* value is needed may depend on the result of sub-issue 1.7, thus can be discussed later. |

**Proposal 1.A:** On unified TCI framework extension, consider at least all the MTPR schemes specified in Rel-16 and Rel-17 as follows:

* Rel-16 M-DCI based MTRP schemes for PDSCH
* Rel-16 S-DCI based PDSCH SDM scheme
* Rel-16 S-DCI based PDSCH FDM and TDM schemes
* Rel-17 S-DCI based PUSCH TDM schemes
* Rel-17 S-DCI based PDCCH repetition scheme
* Rel-17 S-DCI based PUCCH TDM schemes
* Rel-17 PDCCH-SFN and PDSCH-SFN
* Rel-17 inter-cell MTRP
* FFS: Further consider, if supported, Rel-18 MTRP scheme(s) with simultaneous UL transmission across multi-panel

**Proposal 1.B:** On unified TCI framework extension, support up to 2 unified TCI sets in a CC for MTRP operation

* A unified TCI set for joint DL/UL TCI update comprises one indicated joint TCI state that is updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
* A unified TCI set for separate DL/UL TCI update comprises one indicated DL TCI state and/or one indicated UL TCI state that is/are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
* Note: This doesn't imply that the total numbers of indicated DL and UL TCI states must be the same
* FFS: Details of update and activation for the unified TCI sets for S-DCI based MTRP
* FFS: Details of update and activation for the unified TCI sets for M-DCI based MTRP
* FFS: Whether individual TCI update mode (joint or separate DL/UL TCI update) can be supported for each unified TCI set (i.e., one unified TCI set comprises one indicated joint TCI state, and another comprises one indicated DL TCI state and/or one indicated UL TCI state)
* FFS: How to map/apply the unified TCI set(s)to a target channel/signal

**Proposal 1.B-2:** On unified TCI framework extension, support up to 4 indicated TCI states in a CC for MTRP operation

* The indicated TCI states are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
* The UE can be configured/provided with one of the following combinations for DL and/or UL MTRP operations in a CC:
  + - 2 indicated joint TCI states
    - 2 pairs of indicated DL and UL TCI states
    - 1 pair of indicated DL and UL TCI states + 1 indicated DL TCI state
    - 1 pair of indicated DL and UL TCI states + 1 indicated UL TCI state
    - FFS: 1 indicated joint TCI state + 1 pair of indicated DL and UL TCI states
    - FFS: 1 indicated joint TCI state + 1 indicated DL TCI state
    - FFS: 1 indicated joint TCI state + 1 indicated UL TCI state
  + FFS: Details of update and activation for the indicated TCI states for S-DCI based MTRP
  + FFS: Details of update and activation for the indicated TCI states for M-DCI based MTRP
  + FFS: How to map/apply the indicated TCI set(s) to a target channel/signal

**Proposal 1.C**: On unified TCI framework extension, use the existing TCI field in DCI format 1\_1/1\_2 with or without DL assignment to update all indicated TCI states for single-DCI based MTRP

* FFS: Detail of mapping joint/DL/UL TCI states to a TCI field codepoint for all or subset of indicated TCI states, e.g., possible combinations of joint, DL, and/or UL TCI states that can be mapped to a TCI field codepoint for all or subset of indicated TCI states
* FFS: Whether to increase the max number of MAC CE activated TCI field codepoints, i.e., more than 8 codepoints
* FFS: Whether to increase the max number of TCI field bits, i.e., more than 3 bits

Table 2 Additional inputs for Issue 1

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Please check and update your views in Table 1**  **2) Share your inputs on the above moderator proposals** |
| QC | For Proposal 1.A, support  For Proposal 1.B, suggest to add “set”, since each set can include a pair of DL and UL TCIs. Otherwise, it will cause ambiguity in future. Also, each set conceptually corresponds to one TRP.  **Proposal 1.B:** On unified TCI framework extension, support up to 2 unified TCI~~s~~ sets in a CC at least for MTRP operation   * A unified TCI set for joint DL/UL TCI update comprises one indicated joint TCI state that is updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation * A unified TCI set for sperate DL/UL TCI update comprises one indicated DL TCI state and/or one indicated UL TCI state that is/are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation * FFS: Details of update and activation for the unified TCIs for S-DCI based MTRP * FFS: Details of update and activation for the unified TCIs for M-DCI based MTRP * FFS: Whether individual TCI update mode (joint or separate DL/UL TCI update) can be supported for each unified TCI set (i.e., one unified TCI set comprises one indicated joint TCI state, and another comprises one indicated DL TCI state and/or one indicated UL TCI state)   For Proposal 1.C, same comment as for Proposal 1.B  **Proposal 1.C**: On unified TCI framework extension, use the existing TCI field in DCI format 1\_1/1\_2 with or without DL assignment to update both unified TCI sets at least for single-DCI based MTRP   * FFS: How to map joint/DL/UL TCI states to a TCI field codepoint for both unified TCI sets * FFS: Whether to increase the max number of TCI field codepoints/bits, i.e., more than 8 codepoints/3 bits   [Mod] Thanks for the suggestion. Captured! |
| Apple | Proposal 1.A: We suggest we clarify whether R16 mDCI only includes PDSCH?  [Mod] Rel-16 M-DCI supports individual scheduling for each of MTRP. Thus, Rel-16 M-DCI should include PUSCH as well, but just doesn’t support overlapped PUSCH transmissions in time and frequency. The 1st sub-bullet is revised to clarify accordingly, please check whether this is your understanding.  Proposal 1.B: Suggest the following revision, since UE may support mTRP operation for a particular channel instead of all channels.  **Proposal 1.B:** On unified TCI framework extension, support up to 2 unified TCIs in a CC for the channel(s) configured with MTRP operation   * A unified TCI for joint DL/UL TCI update comprises one indicated joint TCI state that is updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation * A unified TCI for sperate DL/UL TCI update comprises one indicated DL TCI state and/or one indicated UL TCI state that is/are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation * FFS: Details of update and activation for the unified TCIs for S-DCI based MTRP * FFS: Details of update and activation for the unified TCIs for M-DCI based MTRP * FFS: Whether individual TCI update mode (joint or separate DL/UL TCI update) can be supported for each unified TCI (i.e., one unified TCI comprises one indicated joint TCI state, and another comprises one indicated DL TCI state and/or one indicated UL TCI state)   [Mod] True, but current proposal doesn't mention which channel/signal should apply the unified TCI(s), that can be the next level discussion in sub-issues 1.11 and 1.12. One FFS is added to clarify the target channel/signal of the supported unified TCI(s) need to be further discussed.  Proposal 1.C: OK with QC’s revision |
| Samsung | **Proposal 1.A**: we are fine with the proposal in principle. We do not support “new” MTRP schemes – for unified TCI framework extension in Rel-18 – in addition to those specified in Rel-16/17. We therefore propose to delete “at least” in the main sentence of this proposal – also given that assuming unified TCI framework for STxMP beam indication has already been captured in the WID.  [Mod] Understood. Then, I would suggest leaving the discussion on whether to consider MTRP schemes introduced in Rel-18 (if specified) later. An FFS is added accordingly, please check.  **Proposal 1.B**: our understanding of the first and second bullets is to define (i) TCI state types applicable for a unified TCI, i.e., a joint TCI state or a pair of separate DL and UL TCI states – same as in Rel-17, and (ii) a generic signaling medium/flow, i.e., MAC CE+DCI analogous to Rel-17, that will be used to indicate/update the 2 unified TCIs (issue #1.4 in Table 1). The first and second bullets, however, may also imply that when the 2 unified TCIs are simultaneously indicated: (1) the 2 unified TCIs can correspond to different TCI state types, e.g., one unified TCI can indicate a joint TCI state, and the other unified TCI can indicate a separate UL TCI state, and (2) signaling medium(s)/flow for updating only one of the 2 unified TCIs has been specified. A note, clarifying that the above (1) and (2) are not implied by the first and second bullets, is needed (and enough). But we are OK to discuss these issues later.  [Mod] Correct understanding! On your 1st issue, it is still an open issue captured in the third FFS and sub-issue 1.5 will be further discussed and decided. On your 2nd issue, this proposal doesn't mean that the two unified TCIs are updated individually. As mentioned by the 1st and 2nd FFS, details on how to update is still open.  **Proposal 1.C**: We are fine to use the existing TCI field in DCI format 1\_1/1\_2 with or without DLA to indicate/update the two TCIs. Regarding the second FFS, from our understanding, increasing the number of TCI states hypotheses does not necessarily result in increasing the number of codepoints of the existing TCI field. Hence, we suggest to also (first) study whether the number of MAC CE activated TCI state codepoints should be increased (i.e., more than 8). We prefer not to increase the DCI payload w.r.t. Rel-17 and a common design for both with and without DLA.  **Proposal 1.C**: On unified TCI framework extension to MTRP operation, use the existing TCI field in DCI format 1\_1/1\_2 with or without DL assignment to update both unified TCIs for single-DCI based MTRP   * FFS: How to map joint/DL/UL TCI states to a TCI field codepoint for both unified TCIs * FFS: Whether to increase the max number of MAC CE activated TCI state codepoints, i.e., more than 8 * FFS: Whether to increase the max number of TCI field codepoints/bits, i.e., more than 8 codepoints/3 bits   [Mod] It is okay to separate increasing # of codepoints and # of bits of field into two FFS. |
| Docomo | Proposal 1.A: Support.  Re Samsung’s comment (removing “at least”), we believe Rel.18 beam indication should also use in unified TCI state (We are open which AI will handle it). In Rel.17, it is not possible to configure both UE features#1 using Rel.17 unified TCI framework and UE features#2 using Rel.15/16 TCI in the same band. We want to avoid this issue happens in Rel.18 again. Hence, all Rel.18 beam indication should use Rel.17 unified TCI framework.  Proposal 1.B: Support (including QC’s update).  Re Apple’s comment, even if UE supports M-TRP operation for a particular channel (e.g. PDSCH), the “indicated TCI states” should be 2, otherwise, it is not possible to indicate 2 TCIs for the particular channel. For other channels which does not support M-TRP operation, one of the two indicated TCI state can be applied.  Proposal 1.C: Support. We don’t clearly understand the difference between 2nd FFS and 3rd FFS, even if we see Samsung’s comment, but we can live with it. |
| Nokia | P1.A: ok  P1.B: ok  P1.C: ok with main bullet. first sub-bullet is not needed to our reading  [Mod] Agree with you that how to map should be clear (by MAC-CE activation). However, there are still some details need to be discussed, e.g., the possible combinations of joint, DL, and/or UL TCI states that can be mapped to a TCI field codepoint. Change the wording a bit, please check. |
| NEC | **Proposal 1.A:** support  **Issue#1.3 in Table 1:** Starting from Rel-17 spec, we only have *DLorJointTCIState* and *UL-TCIState*, so it seems that we don’t need M1/M2 differentiation.  **Proposal 1.B:** It seems that current formulation precludes the case M ≠ N. Based on QC’s revision, we suggest to add the following change - **Proposal 1.B:** On unified TCI framework extension, support up to 2 unified TCIs or 2 unified TCI~~s~~ sets in a CC at least for MTRP operation  [Mod] According to current wording “a unified TCI set for separate DL/UL TCI update comprises one indicated DL TCI state and/or one indicated UL TCI state”. So, it doesn't preclude the possibility that one unified TCI set comprises both indicated DL and UL TCI states and another set comprises only one indicated DL TCI state or UL TCI state, i.e., M≠N. A note is added to clarify, please check.  **Proposal 1.C:** one TCI field in DCI is very limited and cannot handle the case of updating beam(s) for only one of TRPs in a flexible way, we suggest to add FFS on increasing additional TCI field in DCI.  - FFS: Whether to add an additional TCI field  [Mod] Proposal 1.C doesn't preclude TCI update for only one of the TRPs. Please check the FFS, this detail can be further discussed. |
| Ericsson | Proposal 1.A: We are essentially OK, but we prefer to remove “at least”. We note that the WID says “multiple DL and UL TCI states”, so it is not limited to mTRP. We should aim for a solution that works also for sTRP  We are also a little concerned to directly dive into mTRP schemes. The strength of the unified TCI scheme in R17 is that it is very lean and streamlined. Starting with a list could lead to that we start looking into special solutions for all the individual schemes, and this may lead to that a lot of the benefits of the unified TCI are lost. Needless to say, the solutions in for mTRP schemes currently specified are very diverse, and it would be very beneficial to align them.  Proposal 1.B: We would not be OK to introduce the term “TCI state set” – it would just be confusing to have a term that almost means TRP. The benefit is also unclear. The fact remains that we need to indicate 4 TCI states to the UE. If there needs to be a restriction on what types are signalled, that can be added. Also, in Rel-17, we talk about indicated TCI states. We think it is useful to stick with that formulation. “unified TCI” was used as a slogan in Rel-17, but the definition was always a bit unclear.  We propose the following formulation:  **Proposal 1.B:** On unified TCI framework extension, support up to 4 indicated TCIs in a CC at least for MTRP operation   * The TCI states are updated by MAC-CE or indicated by DCI with the necessary MAC-CE based TCI state activation * The UE can be provided with   + 2 joint TCI states   + 1 joint TCI state, 1 DL TCI state and one UL TCI state   + 2 DL TCI states and 2 UL TCI states * FFS: Details of update and activation for the TCI states for S-DCI based MTRP * FFS: Details of update and activation for the TCI states for M-DCI based MTRP * FFS: Whether individual TCI update mode (joint or separate DL/UL TCI update) can be supported for each indicated TCI * FFS: What/how channel(s)/signal(s) applies the unified TCI set(s)   [Mod] Proposal 1.B-2 is added accordingly, with some modifications.  **Proposal 1.C**: On unified TCI framework extension, use the existing TCI field in DCI format 1\_1/1\_2 with or without DL assignment to update all indicated TCI states at least for single-DCI based MTRP   * FFS: How to map joint/DL/UL TCI states to a TCI field codepoint * FFS: Whether to increase the max number of MAC CE activated TCI field codepoints, i.e., more than 8 codepoints * FFS: Whether to increase the max number of TCI field bits, i.e., more than 3 bits   For issue 1.5, we think this is unnecessary, and complicates the interpretation of the DCI field. It may also increase the risk for errors.  Issue 1.6: difficult to motivate additional TCI field: better to increase the size of the single field in that case  Issue 1.7: We are concerned in rushing ahead to design a separate solution for mDCI: the sDCI scheme should work fine. We propose to delay the design of a dedicated mDCI scheme before the sDCI (and sTRP) scheme is designed.  Issue 1.8, Alt2: This is not an extension of the Rel-17 unified TCI framework to handle multiple TCI states, and is hence out of scope. |
| Lenovo | Proposal 1.A: In general we support this proposal. We have the following suggestion:   * The scope shall include R18 MTRP simultaneous UL multi-panel transmission. * R16 MDCI MTRP only supports PDSCH, so PUSCH shall be removed from the first bullet.   [Mod] PUSCH is removed from Rel-16 M-DCI now.  Proposal 1.B: We want to clarify that the “2 unified TCI sets in a CC” refers to the indicated/signaled TCI activated/indicated by MAC-CE/DCI, not the total number of TCI sets that can be activated by MAC-CE or configured in RRC. Is this understanding correct?  [Mod] Correct understanding.  Proposal 1.C: We are OK with it, but the 2nd and 3rd FFS are basically the same and one of them can be removed.  [Mod] Samsung has different understanding on them. Since they are just FFS, let’s keep it. |
| vivo | **Proposal 1.A:** We are fine with the updated proposal in general. For the third sub-bullet, “Rel-16 S-DCI based PDSCH repetition schemes with FDM” doesn’t include the FDM scheme A in our view, because it is not a kind of repetition. Thus, we suggest change it as follows:   * Rel-16 S-DCI based PDSCH FDM scheme A and repetition schemes with FDM scheme B and TDM   [Mod] Yes. Some modifications to avoid missing out.  **Proposal 1.B:** Suggest remove “at least” as we are only study on MTRP operation in WID.  On unified TCI framework extension, support up to 2 unified TCI sets in a CC ~~at least~~ for MTRP operation  **Proposal 1.C:** We have two comments:  1. Update two TCI sets should only work for single-DCI based MTRP, suggest remove “at least”  2. Does the proposal cover the case that only one TCI set of a TRP is to be updated while the TCI set for the other TRP is maintained? To cover this case, we suggest modify the main bullet as follows:  On unified TCI framework extension, use the existing TCI field in DCI format 1\_1/1\_2 with or without DL assignment to update one or both unified TCI sets in a pair of unified TCI sets indicated by the TCI field codepoint ~~at least~~ for single-DCI based MTRP  [Mod] Yes, could be possible, and the 1st FFS in this proposal is intended for this. The detail of mapping joint/DL/UL TCI states to a TCI field codepoint for all or subset of indicated TCI states need to be further discussed. |
| InterDigital | We provided our views in the above table.  **Proposal 1.A:** OK  But, Proposals 1.B & 1.C should be revised, as follows, by removing “set” wording here, since it’s rather confusing to restrict always ‘set’-level simultaneous unified TCI updates unintentionally. But, only one of the unified TCI (from one TRP) may need to be updated separately in time, e.g., for MDCI case. So, it seems risky and premature to always say based on a set-wise description. Further, current Modified P1.A says “support up to 2 unified TCI sets in a CC” which unintentionally sounds unclear in that: in total 4 unified TCIs? which can be indicated or configured?.  Therefore, the following modification is suggested, which seems the FL’s original intension, and we can discuss here based on that “a unified TCI” is what is indicated by a DCI out of up to two unified TCIs (which can be simultaneously indicated by one TCI-codepoint of the DCI for MTRP).  **Proposal 1.B:** On unified TCI framework extension, support indication of up to 2 unified TCIs simultaneously in a CC at least for MTRP operation   * A unified TCI by the indication for joint DL/UL TCI update comprises one indicated joint TCI state that is updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation * A unified TCI by the indication for separate DL/UL TCI update comprises one indicated DL TCI state and/or one indicated UL TCI state that is/are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation * FFS: Details of update and activation for the unified TCI for S-DCI based MTRP * FFS: Details of update and activation for the unified TCI for M-DCI based MTRP * FFS: Whether individual TCI update mode (joint or separate DL/UL TCI update) can be supported for each unified TCI by the indication (i.e., one unified TCI comprises one indicated joint TCI state, and another comprises one indicated DL TCI state and/or one indicated UL TCI state) * FFS: What/how channel(s)/signal(s) applies the unified TCI   **Proposal 1.C**: On unified TCI framework extension, use the existing TCI field in DCI format 1\_1/1\_2 with or without DL assignment to update both unified TCIs at least for single-DCI based MTRP   * FFS: How to map joint/DL/UL TCI states to a TCI field codepoint for both unified TCIs * FFS: Whether to increase the max number of MAC CE activated TCI field codepoints, i.e., more than 8 codepoints * FFS: Whether to increase the max number of TCI field bits, i.e., more than 3 bits   [Mod] Decision on how many TCI states can be indicated by DCI for TCI update is not the intension of Proposal 1.B, which is the next level detail and now captured by the 1st FFS of the updated Proposal 1.C. In Rel-17, one indicated DL TCI state and one indicated UL TCI state are introduced for separate DL/UL TCI update, but it doesn't mean DCI always has to indicate both DL and UL TCI states. Similarly, Proposal 1.B only intends to decide how many indicated joint/DL/UL TCI states can be supported for MTRP operation. |
| FGI | **Proposal 1.A:** It seems that mDCI based MTRP scheme for PUSCH hasn’t been supported neither in Rel-16 or Rel-17, so we suggest that we change the sentence to ‘On unified TCI framework extension, consider ~~at least~~ all the potential MTPR schemes ~~specified in Rel-16 and Rel-17~~ as follows.’  [Mod] PUSCH is removed from Rel-16 M-DCI now.  **Proposal 1.B:** We suggest that we consider this issue as one of FFS:   * FFS: What/how channel(s)/signal(s) applies the unified TCI set(s)and whether different channel(s)/signal(s) could individually apply different number of unified TCI sets   For example, is it possible to apply two unified TCI sets to PDCCH and apply single unified TCI set to PDSCH?  [Mod] Yes, this need to be further discussed. This is the reason “(s)” is put after the unified TCI set.  **Proposal 1.C:** We don’t need to preclude the possibility that adding one TCI field in current stage, and thus it would be better to capture a FFS regarding whether to support additional TCI field in this proposal.  [Mod] Current proposal doesn't preclude the possibility now. |
| Futurewei | **Proposal 1.A:** Support. Our view is similar to Docomo that the extension of Rel-17 unified TCI framework should be applied to all the Rel-16/17/18 (if supported) MTRP schemes to streamline the operation of beam indication/updating.  **Proposal 1.B:** We are in general ok with the proposal.  **Proposal 1.C:** We are in general ok with the proposal. We share the same view as Lenovo that the second and the third FFS are basically the same and one of them can be removed.  [Mod] Samsung has a different understanding on them. Since they are just FFS, let’s keep it. |
| Fraunhofer IIS/Fraunhofer HHI | Proposal 1.A: Support the proposal.  Proposal 1.B: Just a clarification regarding ‘up to 2 unified sets’ in the case of separate DL/UL TCI indication. The second sub-bullet states “A unified TCI set for separate DL/UL TCI update comprises one indicated DL TCI state and/or one indicated UL TCI state.” Does this mean that the indication of 1 DL TCI-state and 2 UL TCI-states, or 2 DL TCI-states and 1 UL TCI-state is possible?  [Mod] According to current wording “a unified TCI set for separate DL/UL TCI update comprises one indicated DL TCI state and/or one indicated UL TCI state”. So, your examples are possible. A note is added to clarify, please check.  Proposal 1.C: Support  Issue 1.5: Tend to agree with Apple that no applicable use-case exists.  Issue 1.7: Ok to discuss both alternatives, but slightly prefer Alt. 1  Issue 1.9: Prefer Alt. 1 for simplicity.  Issue 1.10: The index is better associated with channels instead of TCI-states. So, don’t support.  Issue 1.11 and 1.12: Updated our preferences |
| Mod V1 | **Please also check Proposal 1.B-2 as an alternative of Proposal 1.B according to Ericsson’s suggestion and share your inputs** |
| CATT | Proposal 1.A: Support  Proposal 1.B: Support. Regarding Proposal 1.B-2, we’d like to know why the following combinations are listed as FFS:   * + - FFS: 1 indicated joint TCI state + 1 pair of indicated DL and UL TCI states     - FFS: 1 indicated joint TCI state + 1 indicated DL TCI state     - FFS: 1 indicated joint TCI state + 1 indicated UL TCI state   To our understanding, above cases are included in Proposal 1.B.  Proposal 1.C Support in principle. We have similar view as DCM that the different between the last two FFS are not quite clear.  Regarding Issue 1.10, we also have concern on it. |
| Xiaomi | Proposal 1.A: support  Proposal 1.B/1.B-2: support. For 1.B-2, we support the following three combinations noted as FFS, since each TRP should be configured joint TCI state and separate TCI state independently because of different MPE or interference.   * + - FFS: 1 indicated joint TCI state + 1 pair of indicated DL and UL TCI states     - FFS: 1 indicated joint TCI state + 1 indicated DL TCI state     - FFS: 1 indicated joint TCI state + 1 indicated UL TCI state   Proposal 1.C: what does “for all or subset of indicated TCI states” mean? What is the use case for “subset of indicated TCI states”?  For 1.9, prefer Alt 1  For 1.11, add our view in the table |
| Samsung2 | Regarding the last two FFSs of Proposal 1.C: increasing the number of MAC CE activated codepoints does not necessarily mean that we need to increase the number of ‘TCI’ field bits. Other existing (reserved) DCI fields can be repurposed to indicate additional TCI states/TCI state set – to keep the same DCI payload size. |

# Issue 2 – UL Power Control for UL MTRP

Open issues on UL PC for UL MTRP and company views are summarized below.

Table 3 Summary for Issue 2

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 2.1 | Discussion on Issue 2 should start after simultaneous UL　transmission schemes are determined in AI 9.1.4.1 | Support: Samsung, ZTE, Ericsson  Concern: Nokia | From moderator perspective, sub-issue 2.2 still can be discussed first, at least for Rel-17 UL MTRP |
| 2.2 | Reuse Rel-17 TCI-specific UL PC parameter setting (including PLRS, and per-PUSCH/PUCCH/SRS P0, alpha, CL index) to support per panel/TRP power control | Support: Ericsson, Docomo, OPPO, vivo, Futurewei, Xiaomi, Lenovo, MTK, LGE, Fujitsu, CATT, Apple, Nokia, NEC  Concern: | Given the majority view on this issue, Proposal 2.A is recommended at least for Rel-17 UL MTRP.  How to handle the case if the indicated joint or UL TCI states for S-DCI based UL MTRP are not associated with power control settings can be further discussed |
| 2.4 | Tx power limitation for simultaneous UL transmission | Study per-panel power limit   * Support: Nokia, OPPO, Docomo, Huawei, ZTE, Qualcomm (per-TRP), vivo (LS to RAN4), CATT, Spreadtrum, LGE, Lenovo, CMCC, Apple, NEC * Concern:   Study total power limit shared by two panels   * Support: Huawei, CATT, CMCC, Spreadtrum, Apple ~~(?)~~, Intel, NEC * Concern: |  |

**Proposal 2.A:** 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, closed loop index, and PL-RS), the UE should apply the UL PC parameter setting for the PUSCH/PUCCH transmission occasion.

* FFS: If the indicated joint or UL TCI state is not associated with an UL PC parameter setting for PUCCH/PUSCH
* FFS: Extend to other Rel-18 MTRP scheme(s), if supported

Table 4 Additional inputs for Issue 2

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Please check and update your views in Table 3**  **2) Share your inputs on the above moderator proposal** |
| QC | For Proposal 2.A, support |
| Apple | Support Proposal 2.A.  In addition, added our position on different aspects listed in Table 3 for Issue 2.  On the scheme 2.4, we are open for both schemes, i.e., defining per-TRP power limitation or limiting per serving cell with sharing across two panels. However, for per-TRP power limitation option, we need to send LS to RAN4 to check the feasibility of defining the per-panel max power as it is specified in RAN4 spec. Otherwise, there is risk that RAN1 develops solutions assuming per-panel max power would be introduced, but RAN4 decides to not introduce it for FR2. This happens for FR2-FR2 NR-DC already. |
| Samsung | Support in principle |
| Docomo | Support |
| Nokia | Support |
| NEC | **Proposal 2.A**: support  **Issue#2.4** in table 2, we support to study both and then down-select the most reasonable implementation. We want to check if the following statement is common understanding: if per-panel power limit is assumed, transmit power is doubled for STxMP compared to single panel transmission. |
| Ericsson | **Proposal 2.A:** Support  Issue 2.4: we really do not see how power can be shared between panels. A UE that transmits close to the maximum EIRP limit is unrealistic: realistic UEs will not be limited by EIRP limits, but by the size of the PA.  From 38.101:  The configured UE maximum output power PCMAX,f,c for carrier *f* of a serving cell *c* shall be set such that the corresponding measured peak EIRP PUMAX,f,c is within the following bounds  PPowerclass + PIBE – MAX(MAX(MPRf,c, A- MPRf,c,) + ΔMBP,n, P-MPRf,c) – MAX{T(MAX(MPRf,c, A- MPRf,c,)), T(P-MPRf,c)} ≤ PUMAX,f,c ≤ EIRPmax  So in FR2, PCMAX,f,c is calculated by the UE, based on the EIRP limits. Despite the fact that it is called “configured UE maximum power”, it is not really configured.  Furthermore, we don’t see what we should study. The text in 38.101 applies – this is how the UE determines the its Tx power. |
| Lenovo | **Proposal 2.A**: support  **Issue#2.4** in table 2, we think some clarification for simultaneous multi-panel UL transmission is required from RAN4. From implementation we think there is a hardware limit so the power cannot be shared between two panels. From interference management point of view, both per-panel or per-UE total TX power may be applied. |
| vivo | Support |
| Futurewei | **Proposal 2.A:** Support |
| Fraunhofer IIS/Fraunhofer HHI | Proposal 2.A: Support  Issue 2.1: Agree with the FL’s view  Issue 2.4: Ok to further study both alternatives. |
| Mod V1 | **No change to Proposal 2.A** |
| CATT | Support Proposal 2.A |
| Xiaomi | **Proposal 2.A:** Support.  **Issue 2.4:** Both methods to define the power limit are OK for us. Support to further discuss which one is more feasible. |
|  |  |

# 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 group-based reporting to support simultaneous UL transmission | Support: Qualcomm, Samsung, vivo, MTK, Nokia, Xiaomi  Concern: Apple, Ericsson | This issue can be discussed once any Rel-18 MTRP scheme for simultaneous UL transmission is agreed |
| 3.2 | Extend Rel-17 UE capability correspondence reporting to support simultaneous UL transmission | Support: Samsung, Nokia, CATT, LGE, MTK, AT&T, QC, Apple, Docomo, Lenovo, Xiaomi  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  Concern: Ericsson |  |

Table 6 Additional inputs for Issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please check and update your views in Table 5** |
| QC | We are also fine for 3.2 with table updated |
| Apple | For beam report, in our view, current group based beam report cannot be reused, as it cannot provide enough information for simultaneous transmission. |
| Samsung | We don’t see strong association between supported STxMP tx schemes and beam management for STxMP.  But O.K. to focus on other issues first before we tread this one. |
| Docomo | Added our views in the table. |
| Nokia | Added our views in the table. |
| NEC | We support to study issue#3.3. |
| Ericsson | We are OK to study 3.1 and 3.2 in AI 9.1.4.1. (In our view, 3.1 is needed, 3.2 is not needed). 3.3 is out of scope of the WI. |
| Lenovo | Added our views in the table. |
| vivo | Current description of 3.1 and 3.2 is not clear. Details should be provided for us to make decision. Additionally, we wonder whether 3.1 and 3.2 are exclusive? For example, can extending Rel-17 UE capability correspondence reporting work in group-based beam reporting?  We suggest further study on this issue. |
| Futurewei | Our view is that these issues should be treated with lower priority than those listed under Issues 1 and 2. |
| CATT | We think how to facilitate gNB to know the association of panels and beams should be studied. 3.2 can be studied as a start point. |
| Xiaomi | Added our view in the table, same view with Vivo that 3.1 and 3.2 are two approaches to solve this issue. The use of the index of UE capability value set can be a starting point to facilitate the simultaneous multi-panel transmission. We think this issue is important for STxMP, and we are fine to either discuss here or in AI 9.1.4.1. |

# 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** |
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# Appendix A: Agreements in RAN1#109-e

Void

# 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