**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 2)

**Document for:** Discussion and Decision

# Introduction

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

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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

# 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, ZTE, Intel  Concern: Apple (no use case), 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, OPPO, 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: |  |
| 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 | Given the majority for PDCCH reception in this issue, Proposal 1.E 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 | 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 discussed later. |

## Proposal 1.B: On unified TCI framework extension, support more than one indicated joint/DL/UL TCI states in a CC/BWP for MTRP operation

* 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 apply to the channels/signals that share the “unified TCI” in a CC/BWP
* The indicated joint/DL/UL TCI states are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation
  + Up to 2 indicated joint TCI states can be provided in a CC/BWP for joint DL/UL TCI update
  + Up to 2 indicated DL TCI states can be provided in a CC/BWP for separate DL/UL TCI update
  + Up to 2 indicated UL TCI states can be provided in a CC/BWP for separate DL/UL TCI update
  + FFS: Whether indicated joint TCI state(s) can be provided together with indicated DL TCI state(s) and/or indicated UL TCI state(s) in a CC/BWP, and if applicable, the maximum number of the indicated joint/DL/UL TCI states in the CC/BWP
  + FFS: How to provide 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: 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 two indicated joint/DL/UL TCI states to a target channel(s)/signal(s)

## 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 indicate a set of TCI state IDs for all or subset of indicated joint/DL/UL TCI states in a CC/BWP or a set of CCs/BWPs in a CC list at least for single-DCI based MTRP

* 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 apply to the channels/signals that share the “unified TCI” in a CC/BWP
* FFS: Detail of mapping joint/DL/UL TCI state ID(s) to a TCI field codepoint, e.g., possible combinations of joint, DL, and/or UL TCI state IDs that can be mapped 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
* Note: This doesn't imply that support of one additional TCI field or a field associating the TCI field to the TRP(s) is precluded

## Proposal 1.D: On unified TCI framework extension, support at least one of the following alternatives for multi-DCI based 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 TCI state ID(s) for the indicated joint/DL/UL TCI state(s) respective to the associated *CORESETPoolIndex* value
  + FFS: Association between indicated TCI state(s) and a *CORESETPoolIndex* value, if Alt1 is supported
* Alt2: Use the same TCI state update for single-DCI based MTRP, i.e., use the existing TCI field in any DCI format 1\_1/1\_2 (with or without DL assignment) to indicate a set of TCI state IDs for all or subset of indicated joint/DL/UL TCI states
* 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 TCI state ID(s) for the indicated joint/DL/UL TCI state(s) respective to the same or different *CORESETPoolIndex* value.
  + 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

## Proposal 1.E: At least for single-DCI based MTRP, if more than one indicated DL/joint TCI states in a CC/BWP, an indicator(s) can be signalled RRC to inform the UE which indicated DL/joint TCI state should be applied to PDCCH receptions on the CC/BWP

* FFS: Detail design of the indicator(s), e.g., how to indicate, the indicator(s) is provided per CORESET or per search space set, whether to reuse the existing RRC parameter(s) or introduce a new one, etc.
* FFS: Whether the same indicator(s) is used to inform the UE that two indicated DL/joint TCI states are applied for PDCCH-SFN
* FFS: Whether the same indicator(s) is used for M-DCI based MTRP

Table 2 Additional inputs for Issue 1

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | 1. **Please check the updated Proposal 1.B. To avoid those concerns raised during GTW discussion, the proposal is revised to agree on the maximum numbers first.** 2. **Please share your view on Proposals 1.C, no change from the 1st round discussion** 3. **Please share your view on new Proposal 1.D and 1.E** |
| Ericsson | Proposal 1.B: Support  Proposal 1.C: Propose to add “at least”: [Mod] okay 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 or subset of indicated TCI states in a CC/BWP or a set of CCs/BWPs at least for single-DCI based MTRP Proposal 1.D: Do not support. We should avoid stating alternatives this early. Wait until further development of the sDCI solution has been performed – then we can compare solutions.  Proposal 1.E: Support with a slight edit: Proposal 1.E: When the UE is indicated with more than one DL/joint TCI states in a CC/BWP, support an indicator by RRC signaling to inform the UE which indicated DL/joint TCI state should be applied to PDCCH receptions on the CC/BWP [Mod] Revised. Please check. |
| Futurewei | **Proposal 1.B:** Support.  **Proposal 1.C:** Support. We are also fine with Ericsson’s proposed modification.  **Proposal 1.D:** Support.  **Proposal 1.E:** We would like to have some clarifications on this proposal. First, to our understanding, this proposal is for S-DCI based MTRP as it is based on discussion on Issue 1.11. So we suggest adding “for single-DCI based MTRP” in the main bullet. Second, if existing RRC parameter(s) are reused as stated in the first FFS, depending on the scenario, it is possible that different parameter will be used for different scenario, instead of using just one single parameter. Therefore we would like to make the following modifications:  [Mod] Since there are still some companies prefer a unified scheme for S-DCI and M-DCI, thus whether this can be used for M-DCI still can be left for further studied Proposal 1.E: When the UE is provided with more than one indicated DL/joint TCI states in a CC/BWP for single-DCI based MTRP, support utilizing indicator(s) by RRC signaling to inform the UE which indicated DL/joint TCI state should be applied to PDCCH receptions on the CC/BWP  * FFS: Detail design of the indicator(s), e.g., how to indicate, the indicator(s) are provided per CORESET or per search space set, whether to reuse the existing RRC parameter(s) or introduce a new one, etc. * FFS: Whether the same indicator(s) are used to inform the UE that two indicated DL/joint TCI states are applied for PDCCH-SFN |
| Xiaomi | Proposal 1.B: support  Proposal 1.C: For the main bullet, we have two comments. First one, here only TCI update is mentioned, what about the first time indication? Second one, here mentioned all or subset, does it mean there is a reference set? Without the reference set, it is meaningless to talk about all or subset of indicated TCI states. According to the response from feature lead, the reference set will be decided by TCI mode. But from Proposal 1.B, we can see that TCI mode can be provided by the indicated TCI codepoint, TCI state activation, or RRC configuration. So if to keep “all or subset”, we suggest to define the reference set first. But from our point of view, the reference set can be defined if the TCI mode is provided by RRC configuration. While for the case of provided by the indicated TCI codepoint or TCI state activation, it is difficult to define it. So the simplest way is to remove “all or subset”.  [Mod] Revision to replace “update”, please check. And I add a note to clarify the term “indicated TCI states”.  Proposal 1.D: Alt 2 is not clear. We suggest to update it as below: Proposal 1.D: On unified TCI framework extension, support at least one of the following alternatives for multi-DCI based 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 update the indicated TCI state(s) respective to the associated *CORESETPoolIndex* value   + FFS: Association between indicated TCI state(s) and a *CORESETPoolIndex* value, if Alt1 is supported * Alt2: Use the ~~same TCI state update for single-DCI based MTRP, i.e., use the~~ existing TCI field in ~~any~~ DCI format 1\_1/1\_2 (with or without DL assignment) associated with one of *CORESETPoolIndex* values to update ~~all or subset of~~  the indicated TCI state(s) for any one or two of *CORESETPoolIndex* values.   [Mod] Alt3 is added accordingly  Proposal 1.E: first we share same view as Samsung that ‘S-DCI based M-TRP’ should be added. In addition, we prefer to use ‘which indicated DL/joint TCI state(s)’ since PDCCH repetition and PDCCH-SFN should also be considered. Thirdly, we are not sure RRC signaling is sufficient or not, whether an association between TCI state(s) and TRP is necessary. So we suggest to add a FFS that “an association between TCI state(s) and TRP”.  [Mod] How to support PDCCH-SFN by this proposal is captured in the 3rd FFS. On the association between TCI state(s) and TRP, it can be studied as a part of detail design of the indicator(s). |
| DOCOMO | **Proposal 1.B:** Support. If other Rel.18 agenda (e.g. CJT) requires larger number of TRPs, we can discuss it later. The current description of “More than one indicated joint/DL/UL TCI states” is very general, hence, we support to list the supported combination as in FL proposal.  **Proposal 1.C:** Support.  **Proposal 1.D:** Support. We support Alt.1. We think Alt.2 is not suitable for non-ideal backhaul that one DCI from one TRP indicates two TCI states for both TRPs.  **Proposal 1.D:** Support. We are ok with limiting the proposal to S-DCI. While we are also ok to cover both S-DCI and M-DCI, but in that case, “an indicator by RRC signaling” can be existing CORESETPoolIndex for M-DCI.  For SFN-CORESET, no indicator is needed in case of 2 indicated TCI states, but indication would be needed if more than 2 indicated TCI states are indicated. Hence, we support to study for SFN-CORESET. |
| Apple | Proposal 1.B: We suggest the following revision. In our view, this is for channels that share the indicated unified TCI state. The first 2 FFS seems to be unclear. We suggest removing them. Proposal 1.B: On unified TCI framework extension, for channels that share the indicated unified TCI state, support more than one indicated joint/DL/UL TCI state IDs in a CC/BWP or in CCs in a CC list for MTRP operation  * The TCI states IDs can be indicated by MAC-CE or DCI format 1\_1/1\_2   + Up to 2 joint TCI state IDs can be indicated for joint DL/UL TCI update   + Up to 2 DL TCI state IDs can be indicated for separate DL/UL TCI update   + Up to 2 UL TCI state IDs can be indicated for separate DL/UL TCI update   + 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 one or two indicated TCI states to a target channel(s)/signal(s)   [Mod] This proposal is not intended to decide the number of TCI state IDs that can be indicated by a TCI state codepoint. Instead, it is intended for the number of joint/DL/UL TCI states that UE needs to maintain at the same time and apply to the channels/signals that share the “unified TCI” in a CC/BWP. A note is added in the proposal to clarify the term “indicated TCI states”, which follows the concept in current spec for Rel-17 unified TCI framework.  Proposal 1.C: Support in principle. We suggest the following minor change. 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 or subset of indicated TCI states in a CC/BWP or a set of CCs/BWPs in a CC list for single-DCI based MTRP  * FFS: Detail of mapping joint/DL/UL TCI states to a TCI field codepoint, e.g., possible combinations of joint, DL, and/or UL TCI states that can be mapped 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 * Note: This doesn't imply that support of one additional TCI field or a field associating the TCI field to the TRP(s) is precluded   [Mod] Thanks. It is more clear.  Proposal 1.D: Suggest adding Alt3 to support cross-TRP beam indication. Proposal 1.D: On unified TCI framework extension, support at least one of the following alternatives for multi-DCI based 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 update the indicated TCI state(s) respective to the associated *CORESETPoolIndex* value   + FFS: Association between indicated TCI state(s) and a *CORESETPoolIndex* value, if Alt1 is supported * Alt2: Use the same TCI state update for single-DCI based MTRP, i.e., use the existing TCI field in any DCI format 1\_1/1\_2 (with or without DL assignment) to update all or subset of indicated TCI states * Alt3: 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 update the indicated TCI state(s) respective to the associated *CORESETPoolIndex* value or the other *CORESETPoolIndex*   + Whether the indicated TCI state(s) are applied to the channels associated with the same *CORESETPoolIndex* or the other *CORESETPoolIndex* is indicated by DCI   [Mod] Added  Proposal 1.E: In our view, the beam indication should still be in CORESET level, otherwise it would create new mTRP schemes. We suggest the following revision. Proposal 1.E: When the UE is provided with more than one indicated DL/joint TCI states in a CC/BWP, if mTRP PDCCH repetition is enabled, support an indicator by RRC signaling for CORESET(s) that share the indicated DL/joint TCI states to inform the UE which indicated DL/joint TCI state should be applied to the CORESET(s) on the CC/BWP  * FFS: Detail design of the indicator, e.g., how to indicate, the indicator is provided per CORESET or per search space set, whether to reuse the existing RRC parameter or introduce a new one, etc. * FFS: Whether the same indicator is used to inform the UE that two indicated DL/joint TCI states are applied for PDCCH-SFN * FFS: Whether the same indicator is used for both S-DCI and M-DCI based MTRP   [Mod] Some companies propose to use the same indicator to M-DCI, thus let’s keep it open now. On CORESET vs.. SS set, even I share similar view with you, but we can decide it later. |
| Fujitsu | Proposal 1.B: Support.  Proposal 1.C: Support.  Proposal 1.D: Support.  Proposal 1.E: Does the sentence “When the UE is provided with more than one indicated DL/joint TCI states in a CC/BWP” mean that the indicator is supported under the condition that the UE has been provided with more than one TCI state? If it is not the intention, we suggest to delete this sentence. Proposal 1.E: ~~When the UE is provided with more than one indicated DL/joint TCI states in a CC/BWP, s~~Support an indicator by RRC signaling to inform the UE which indicated DL/joint TCI state should be applied to PDCCH receptions on the CC/BWP  * FFS: Detail design of the indicator, e.g., how to indicate, the indicator is provided per CORESET or per search space set, whether to reuse the existing RRC parameter or introduce a new one, etc. * FFS: Whether the same indicator is used to inform the UE that two indicated DL/joint TCI states are applied for PDCCH-SFN   FFS: Whether the same indicator is used for both S-DCI and M-DCI based MTRP  [Mod] Yes, the intension is what you mention. Precisely speaking, when more than one joint/DL TCI states that UE needs to maintain and apply to the channels/signals at the same time, the indicator is used to indicate which one is applied for PDCCH reception. |
| Mod V1 | 1. **Please check the updated Proposal 1.B. To avoid those concerns raised during GTW discussion, the proposal is revised to agree on the maximum numbers first. Meanwhile, a note is added in the proposal to clarify the term “indicated TCI states”, which follows the concept in current spec for Rel-17 unified TCI framework.** 2. **Please share your view on the updated Proposal 1.C 1.D and 1.E** |
| vivo | **Proposal 1.B:** We have following comment:   * We assume the first FFS is related to whether different TCI modes are allowed for two TRPs, i.e., indicate one joint TCI state for TRP1 and one DL and/or UL TCI state for TRP2, so “(s)” is not needed. What’s more, there is no need to discuss “the maximum number of the indicated joint/DL/UL TCI states”, because we have the condition one indicated joint TCI state + one indicated DL/UL indicated state. * For the second FFS, is it intended to clarify our concern in the GTW? For example, a UE is firstly indicated two joint TCI states, and then the UE is indicated one joint TCI state. Does it mean the UE is switched to STRP transmission or still maintain MTRP with one updated joint TCI state and one kept joint TCI state? If this is to clarify our concern, we are OK with this FFS.  Proposed update of Proposal 1.B: On unified TCI framework extension, support more than one indicated joint/DL/UL TCI states in a CC/BWP for MTRP operation  * 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 apply to the channels/signals that share the “unified TCI” in a CC/BWP * The indicated joint/DL/UL TCI states are updated by MAC-CE or DCI with the necessary MAC-CE based TCI state activation   + Up to 2 indicated joint TCI states can be provided in a CC/BWP for joint DL/UL TCI update   + Up to 2 indicated DL TCI states can be provided in a CC/BWP for separate DL/UL TCI update   + Up to 2 indicated UL TCI states can be provided in a CC/BWP for separate DL/UL TCI update   + FFS: Whether one indicated joint TCI state~~(s)~~ can be provided together with one indicated DL TCI state~~(s)~~ and/or one indicated UL TCI state~~(s)~~ in a CC/BWP~~, and if applicable, the maximum number of the indicated joint/DL/UL TCI states in the CC/BWP~~   + FFS: How to provide 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: 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 two indicated joint/DL/UL TCI states to a target channel(s)/signal(s)   **Proposal 1.C:** Support  **Proposal 1.D:** A single solution for M-DCI based MTRP is highly desired, suggest remove “at least”. And we prefer Alt1. Proposed update of Proposal 1.D: On unified TCI framework extension, support ~~at least~~ one of the following alternatives for multi-DCI based 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 update the indicated TCI state(s) respective to the associated *CORESETPoolIndex* value   + FFS: Association between indicated TCI state(s) and a *CORESETPoolIndex* value, if Alt1 is supported * Alt2: Use the same TCI state update for single-DCI based MTRP, i.e., use the existing TCI field in any DCI format 1\_1/1\_2 (with or without DL assignment) to update all or subset of indicated TCI states   **Proposal 1.E:** We have following comments:   * Better to separate the S-DCI based MTRP and M-DCI based MTRP discussion because they may have different indications. * For S-DCI-based MTRP, there is no existing RRC parameter in our view and it should be removed. * We think indicator provided per CORESET is reasonable based on Rel-17 unified TCI framework. * For M-DCI-based MTRP, the existing RRC parameter is CORESETPoolIndex in our view and there is no support of PDCCH-SFN.  Proposed update of Proposal 1.E: When the UE is provided with more than one indicated DL/joint TCI states in a CC/BWP, support an indicator by RRC signaling to inform the UE which indicated DL/joint TCI state should be applied to PDCCH receptions on the CC/BWP  * For S-DCI-based MTRP:   + FFS: Detail design of the indicator, e.g., how to indicate, the indicator is provided per CORESET ~~or per search space set, whether to reuse the existing RRC parameter or introduce a new one~~, etc.   + FFS: Whether the same indicator is used to inform the UE that two indicated DL/joint TCI states are applied for PDCCH-SFN * ~~FFS: Whether the same indicator is used for both S-DCI and M-DCI based MTRP~~ * For M-DCI-based MTRP:   + FFS: ~~Detail design of the indicator, e.g., how to indicate, the indicator is provided per CORESET or per search space set,~~ whether to reuse ~~the existing RRC parameter~~ CORESETPoolIndex or introduce a new one, etc. |
| Samsung | **Proposal 1.B**: For multi-TRP, we do not see use cases of having 2 joint TCI states or 2 DL TCI states or 2 UL TCI states per TRP. We therefore suggest the following edits for the potential TCI state modes. We are OK to further study whether joint and separate can be indicated together as stated in the first FFS.   * + Up to 2 indicated joint TCI states (up to 1 per TRP) can be provided in a CC/BWP for joint DL/UL TCI update   + Up to 2 indicated DL TCI states (up to 1 per TRP) can be provided in a CC/BWP for separate DL/UL TCI update   + Up to 2 indicated UL TCI states (up to 1 per TRP) can be provided in a CC/BWP for separate DL/UL TCI update  For Proposal 1.C, we think with the following wording edit, the note in the last bullet can be removed.Proposal 1.C: On unified TCI framework extension, use at least the existing TCI field in DCI format 1\_1/1\_2 (with or without DL assignment) to indicate a set of TCI state IDs for all or subset of indicated joint/DL/UL TCI states in a CC/BWP or a set of CCs/BWPs in a CC list at least for single-DCI based MTRP  * 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 apply to the channels/signals that share the “unified TCI” in a CC/BWP * FFS: Detail of mapping joint/DL/UL TCI state ID(s) to a TCI field codepoint, e.g., possible combinations of joint, DL, and/or UL TCI state IDs that can be mapped 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 Proposal 1.D, support.For Proposal 1.E, we prefer FL’s previous version – ‘signalling’ is unclear.Proposal 1.E: At least for single-DCI based MTRP, if more than one indicated DL/joint TCI states in a CC/BWP, use RRC indicator(s) to inform the UE which indicated DL/joint TCI state should be applied to PDCCH receptions on the CC/BWP  * FFS: Detail design of the indicator(s), e.g., how to indicate, the indicator(s) is provided per CORESET or per search space set, whether to reuse the existing RRC parameter(s) or introduce a new one, etc. * FFS: Whether the same indicator(s) is used to inform the UE that two indicated DL/joint TCI states are applied for PDCCH-SFN * FFS: Whether the same indicator(s) is used for M-DCI based MTRP |
| CATT | **Proposal 1.B:** Support.  **Proposal 1.C:** Support. The first FFS seems to be redundant, since it is similar as the second FFS of Proposal 1.B. If the understanding is correct, we prefer to remove the first FFS.  **Proposal 1.D:** Support.    **Proposal 1.E:** Support. Whether the indicator is used for both S-DCI and M-DCI based MTRP depends on the outcome of Proposal 1.D. |
| Spreadtrum | **Proposal 1.B:** Support.  **Proposal 1.C:** Support. It is more clear after the note for “indicated TCI” is added, thanks.  **Proposal 1.D:** Support. Cross-TRP beam indication should be discussed.  **Proposal 1.E:** Support in principle and we think that S-DCI and m-DCI based MTRP could be discussed separately. |
| LG | Proposal 1.B/C/D: Support  Proposal 1.E: Fine in principle. Regarding the first FFS, we suggest the following as an example for the design of the indication (red text) by: Proposal 1.E: At least for single-DCI based MTRP, if more than one indicated DL/joint TCI states in a CC/BWP, an indicator(s) can be signalled RRC to inform the UE which indicated DL/joint TCI state should be applied to PDCCH receptions on the CC/BWP  * FFS: Detail design of the indicator(s), e.g., how to indicate, the indicator(s) is provided per CORESET or per search space set or per CORESET pool in case of M-DCI MTRP, whether to reuse the existing RRC parameter(s) or introduce a new one, etc. |

# 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, Huawei, HiSilicon, Intel  Concern: Nokia, LG | 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, TransHold, Intel  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, TransHold * Concern:   Study total power limit shared by two panels   * Support: Huawei, CATT, CMCC, Spreadtrum, Apple, Intel, NEC, OPPO, ZTE, LG, TransHold * Concern: |  |
| 2.5 | Send LS to RAN4 to check the feasibility for above two cases | Support: vivo, Apple, Lenovo, QC, CMCC, Xiaomi, DOCOMO, Futurewei, Ericsson, Fujitsu  Concern: |  |

## Proposal 2.B: Send LS to RAN4 to check the feasibility of the followings:

* Power limitation per-panel for simultaneous UL transmission across multiple UE panes
* A total power limitation that is shared by multiple UE panels used for simultaneous UL transmission

Table 4 Additional inputs for Issue 2

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your inputs on sub-issue 2.5 and Proposal 2.B** |
| Samsung | The reason to send LS is not clear, since many companies share view that both scenario could be studied in RAN1. Unless strong concerns are found in either scenario, we may not need to send LS to RAN4.  But we would respect majority views. |
| Ericsson | OK. |
| Futurewei | Fine with FL proposal. |
| Apple | Support FL proposal.  As explained in the 1st round, the per-panel power control option (i.e., the 1st sub-bullet) is feasible on condition that RAN4 plans to define a new panel-specific maximum transmission power, which is NOT available in current RAN4 FR2 spec. |
| Xiaomi | Support proposal 2.B. |
| DOCOMO | Fine with FL proposal. |
| Fujitsu | We are fine with the proposal. |
| vivo | Fine with the proposal. |
| CATT | Support proposal 2.B.  Just one suggestion on a minor editorial issue: Proposal 2.B: Send LS to RAN4 to check the feasibility of the followings:  * Power limitation per-panel for simultaneous UL transmission across multiple UE panels * A total power limitation that is shared by multiple UE panels used for simultaneous UL transmission |
| Spreadtrum | Support. |
| LG | Fine in general with the proposal. There’s a small typo in the first bullet (i.e. across multiple UE panels).  In our view, it is also possible to have both assumption, i.e. per-panel power limit + per UE power limit for a UE, so we suggest to include that question in the LS as well. |

# 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 |  |

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. |
| OPPO | Add our concern on Issue 3.1 that group-based reporting is based on DL operation in which UE may apply single Rx beam for receiving two DL beams. As for STxMP, such group-based reporting cannot be simply feasible for UL transmission.  On Issue 3.2, we think it’s time to remove the artificial constraint on UE capability value set reporting. But we are fine to hold a while until there are progresses on STxMP in other AI. |
| ZTE | Please review our position in the above table. Generally speaking, we tend to agree with Samsung. We can first focus on the discussion of issue 1 and 2, and then consider issue 3 after they are stable. |
| QC | Among all 3 issues, we suggest to prioritize issue 3.1, which is needed for simultaneous UL beam Tx.   * To Apple/OPPO, agree the current group-based report cannot be reused. Our understanding is that the issue 3.1 is to investigate how to make it work * To E///, we think the beam reporting issue should be treated in 9.1.1.1, since 9.1.4.1 is mostly for non-beam related issues, e.g. precoder as in the WID |
| Fujitsu | In our view, beam reporting should at least be able to distinguish STxMP scheme and panel selection/TDM-based scheme. In that sense, we are also open to the beam reporting 3.1 and 3.2. |
| Spreadtrum | We support 3.3 with table updated. Same view as vivo, we think the scheme in issue 3.1 and 3.2 could be described in detail before we have further discussion. |
| CMCC | At this stage, both 3.1 and 3.2 can be viewed as potential way to facilitate simultaneous UL transmission. For issue 3.3, we support to study it in this AI. |
| Transsion | Added our views in the table. |
| Samsung | We support 3.3 BFR enhancements. We think it is within the scope. |
| Huawei, HiSilicon | **3.1:** Support.  **3.2:** Just to clarify, does the “UE capability correspondence reporting” refers to the capability value based reporting? If so, then we can support it.  [Mod] Yes. Wording is revised to avoid confusion.  **3.3:** Ok to support. |
| Intel | **3.1** can be studied. Others are of lower priority and should be discussed after STxMP schemes are discussed in 9.1.4.1. Ideally 3.2 should be discussed in 9.1.4.1. |
| Mod V1 | Revised wording for sub-issues 3.1 and 3.2 to avoid confusion |
| Samsung | As response to Ericsson, for further clarification,  TRP specific BFR enhancement in Rel-18 should focus on the possible issues raised by extending unified TCI framework to cover MTRP. So the procedure(s) of BFR not related to beam indication/update under MTRP unified TCI framework would be excluded in the discussion.  In addition, please be noted that with unified TCI, most beam management or related operations should be associated with TCI state, and operation per TCI state should be the baseline (and potential BFR enhancements can be progressed along with the progress of issue 1 beam indication/update). While in current design, without modification, BFR would be the only exception.  I hope this explanation can verity why TRP specific BFR can be discussed within the scope. |
| CATT | As captured in the above table, we support 3.2. |
| LG | For STxMP, we firstly need to remove artificial constraints of UE capability value, i.e. it is only applicable to MPUE having different number of ports across panels. Otherwise, gNB has no information on preferred UL beams for each panel which is fundamental information for STxMP BM. Thus, we suggest to prioritize 3.2. |

# 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