3GPP TSG RAN WG1 #104-e R1-200xxxx

e-Meeting, January 25th – February 05th, 2021

**Agenda item: 8.1.2.1**

**Source:** **Moderator (Nokia, Nokia Shanghai Bell)**

**Title: Summary #3 of Multi-TRP for PUCCH and PUSCH**

**Document for: Discussion and Decision**

# Introduction

Previous versions of FL summaries are listed below,

**R1-2101784** Summary of Multi-TRP for PUCCH and PUSCH Moderator (Nokia, Nokia Shanghai Bell)

**R1-2101900** Summary #2 of Multi-TRP for PUCCH and PUSCH Moderator (Nokia, Nokia Shanghai Bell)

The remaining discussions are summarized in Section 2 and 3, where section 2 has proposals coming from Phase #1/#2, and Section 3 contain two new proposals.

Colour coding,

* Proposals coming from Phase 1 and 2: highlighted.
* New proposals: highlighted
* FL comments: highlighted

# Remaining proposals

## 2.1 Proposals coming from Phase #1 and #2

For both PUCCH and PUSCH TPC command enhancements, Option 3 is the majority view, but the group is not yet ready to make the down selection. Depending on online time availability, RAN1 could agree on one option (the majority is option 3) or keep everything alive for the next meeting.

**Proposal 2.4-A:**

Further study following alternatives to support per TRP closed-loop power control for PUCCH, select one from the below options based on the majority support during the RAN1 #104-e-bis meeting.

* Option.1: A single TPC field (the existing TPC field) is used in DCI formats 1\_1 / 1\_2, and the TPC value applied for both PUCCH beams
* Option.2: A single TPC field (the existing TPC field) is used in DCI formats 1\_1 / 1\_2, and the TPC value applied for one of two PUCCH beams at a slot. The TPC value may be applied for the other PUCCH beam at an another slot.
* **Option 3: A second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2.**
* Option 4: A single TPC field is used in DCI formats 1\_1 / 1\_2, and indicates two TPC values applied to two PUCCH beams, respectively.

Please comment on preferred changes to the proposal or if you object.

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| **Company** | **Comments** |
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**Proposal 2.4-B:**

Further study following alternatives to support per TRP closed-loop power control for PUSCH, select one from the below options based on the majority support during the RAN1 #104-e-bis meeting.

* Option.1: A single TPC field (the existing TPC field) is used in DCI formats 0\_1 / 0\_2, and the TPC value applied for both PUSCH beams
* Option.2: A single TPC field (the existing TPC field) is used in DCI formats 0\_1 / 0\_2, and the TPC value applied for one of two PUSCH beams at a slot.
* **Option 3: A second TPC field (similar to the existing TPC field) is added in DCI formats 0\_1 / 0\_2.**
* Option 4: A single TPC field is used in DCI formats 0\_1 / 0\_2, and indicates two TPC values applied to two PUSCH beams, respectively.

Please comment on preferred changes to the proposal or if you object

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Beam mapping or power control parameter set mapping can follow the same method as Scheme 1 beam mapping methods.

**Proposal for working assumption 2.7:**

For beam mapping /power control parameter set mapping for PUCCH repetitions,

* For M-TRP PUCCH Scheme 1 in FR1, it is possible to configure either cyclic mapping or sequential mapping of power control parameter sets over PUCCH repetitions (similar to spatial relation info’s over PUCCH repetitions).
* For M-TRP PUCCH Scheme 3, reuse the same methods as Scheme 1 (by replacing slots with sub-slots) for beam mapping or power control resource set mapping to sub-slots.
* This working assumption is also subjected to the RAN4 LS R1-2009807 and confirmed based on the RAN4 reply.

Please comment on preferred changes to the proposal or if you object

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DMRS-PTRS mapping was also discussed in phase 1, and the majority support the following.

**Proposal 3.4:** For single DCI based M-TRP PUSCH repetition schemes, the number of bits for the indication of PTRS-DMRS association is the same as Rel-15/16.

* For maxRank = 2, MSB and LSB separately indicating the association between PTRS port and DMRS port for two TRPs.
* FFS: Interpretation for other scenarios when maxRank > 2.

Please comment on preferred changes to the proposal or if you object

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| **Company** | **Comments** |
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The following was discussed many times during the last few meetings and this meeting and should be able to conclude given the majority view.

**Conclusion**

The dynamic indication of the number of repetitions supported for Rel-17 coverage enhancement can be used for multi-TRP operation.

Please comment on preferred changes to the proposal or if you object.

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| **Company** | **Comments** |
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## 2.2 Proposals on SRI and TPMI indications

FL kept the phase #2 discussion on SRI and TPMI to enable down-selection in this meeting.

### Proposal 3.1

**Proposal 3.1-A:** For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,

* Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.
  + **Option 1:** Each SRI field indicating SRI per TRP, where the SRI field based on Rel-15/16 framework
  + **Option 2**: One enhanced SRI field indicating two SRIs
    - FFS: details of enhanced SRI field including the specification effort to replace Table 7.3.1.1.2-32/32A/32B in 38.212.
* Support dynamic switching between multi-TRP and single-TRP operation
  + **For Option 1 - Alt1:** by using two SRI fields at least when there is a reserved entry for one SRI field.
    - When the SRI fields do not have a reserved entry, the dynamic switching cannot be supported.
    - FFS: whether to support dynamic switching if the SRI fields does not have a reserved entry
  + **For Option 1 - Alt2 :** by using two SRI fields or TPMI field(s).
    - FFS: Additional details of SRI/TPMI field interpretations
  + **For Option 2:** by using one enhanced SRI field or TPMI field(s).
    - FFS: Additional details of SRI field interpretations

**Proposal 3.1-B:** For single DCI based M-TRP PUSCH repetition schemes, in non-codebook based PUSCH,

* Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.
  + **Option 1:** Each SRI field indicating SRI per TRP, where the SRI field based on Rel-15/16 framework
  + **Option 2:** Each SRI field indicating SRI per TRP, where the first SRI field based on Rel-15/16 framework, the second SRI field does not indicate the number of layers
    - FFS: details of second SRI field including the specification change for Table 7.3.1.1.2-28/29/30/31 in 38.212.
  + **Option 3**: One enhanced SRI field indicating two SRIs
    - FFS: details of enhanced SRI field including the specification effort to replace Table 7.3.1.1.2-28/29/30/31 in 38.212.
* Support dynamic switching between multi-TRP and single-TRP operation
  + **For Option 1:** by using two SRI fields at least when there is a reserved entry for one SRI field.
    - When the SRI fields does not have a reserved entry, the dynamic switching cannot be supported.
    - FFS: whether to support dynamic switching if the SRI fields does not have a reserved entry
  + **For Option 2:** by using one or two SRI field(s)
    - FFS: Additional details of SRI field(s) interpretations
  + **For Option 3:** by using one enhanced SRI field.
    - FFS: Additional details of SRI field interpretations
* FFS: Minimizing the DCI overhead for PUSCH repetition Type A as a result of number of layers being limited to 1 when more than one repetition is scheduled.

This discussion is copied from Phase #2, and please see the bottom of the table for the FL update.

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| **Company** | **Comments** |
| LG | We would like to continue comparing payload size and scheduling restriction of what companies have in mind. We share our design and provide bit size in the Table below.   * A single joint field   + Supporting dynamic switching among STRP1, STRP2, MTRP   + Assuming the same rank restriction between MTRP PUSCHs.   + Not supporting dynamic switching the order of TRP for MTRP transmission   It would be appreciated if other companies share their detail design and provide bit size in the Table.  **Table for payload size of NCB SRI field(s) (without SRI ordering switching)**   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | Lmax=1 | | | | Lmax=2 | | | | Lmax=3 | | | | Lmax=4 | | | | |  | Nsrs=1 | Nsrs=2 | Nsrs=3 | Nsrs=4 | Nsrs=1 | Nsrs=2 | Nsrs=3 | Nsrs=4 | Nsrs=1 | Nsrs=2 | Nsrs=3 | Nsrs=4 | Nsrs=1 | Nsrs=2 | Nsrs=3 | Nsrs=4 | | LG  vivo | 2 | 3 | 4 | 5 | 2 | 4 | 5 | 7 | 2 | 4 | 6 | 7 | 2 | 4 | 6 | 7 | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |   **Table for payload size of NCB SRI field(s) (with SRI ordering switching)**   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | Lmax=1 | | | | Lmax=2 | | | | Lmax=3 | | | | Lmax=4 | | | | |  | Nsrs=1 | Nsrs=2 | Nsrs=3 | Nsrs=4 | Nsrs=1 | Nsrs=2 | Nsrs=3 | Nsrs=4 | Nsrs=1 | Nsrs=2 | Nsrs=3 | Nsrs=4 | Nsrs=1 | Nsrs=2 | Nsrs=3 | Nsrs=4 | | vivo | 2 | 4 | 5 | 6 | 2 | 4 | 6 | 7 | 2 | 4 | 6 | 8 | 2 | 4 | 6 | 8 | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | |
| ZTE | * Regarding CB-related Proposal 3.1-A, we support option 1 - Alt2.   For CB PUSCH in Rel-15/16, SRI is used to indicate SRS selection and TPMI is used to indicate precoder and rank. W.r.t. single-DCI based MTRP PUSCH, the design of both SRI and TPMI should be considered simultaneously for DCI overhead, STRP/MTRP dynamic switching, configured mapping of SRI and PC parameter sets, etc.  As we introduced in phase 1, exploit two entries in 2nd TPMI field can enable STRP/MTRP dynamic switching as well as minimizing DCI overhead. Besides, the mapping between SRIs and TRPs can be crystal clear. More specifically, when MTRP operation, two TPMI fields towards two TRPs/ SRS resource sets, respectively. When STRP operation, one entries in 2nd TPMI filed indicate PUSCH towards which one out of two TRPs, then 1st TPMI field indicate the specific TPMI value. Based on that, two SRI fields can be same to based on Rel-16 for minimizing DCI overhead.  For example, when STRP and configure only one SRS in each SRS resource set, such as SRS resource set {SRS 0} and SRS resource set 1 {SRS 0}, the DCI overhead of SRI fields is 0bit due to 2nd TPMI field can used for specific TRP/SRS resource set selection, which means up to 2bits can be saved versus single joint SRI field. For one clarification, when at least two entries are reserved in 2nd TPMI filed, 1 bit or 2 bits can be saved compared with other solutions. When less than two entries are reserved in 2nd TPMI field and one or two new entries should be enabled, 1 bit can be saved compared with option 2 and overhead is equal to option1 - Alt1.   * Regarding NCB-related Proposal 3.1-B, we support Option 2.   For NCB PUSCH in Rel-15/16, only SRI is used to indicate SRS selection, SRS port number, precoder and rank. From the prospective of rank indication, unified design of CB and NCB PUSCH should be adopted, due to it is enough to use both 1st TPMI field of CB PUSCH and 1st SRI field of NCB PUSCH to indicate rank value.  For STRP/MTRP dynamic switching, we also can use unified design of CB and NCB PUSCH, where two entries in 2nd SRI field can be exploited. Likewise, the method can guarantee minimized DCI overhead and indicate the mapping between SRIs and TRPs no matter STR or MTRP operation.  From technical prospective, two SRI fields and two TPMI fields for CB and NCB PUSCH with such advantages as follows: (1) adopt the unified design for rank indication for both codebook and non-codebook based PUSCH, (2) enable dynamic switching between STR and MTRP and minimize the DCI overhead as much as possible, (3) clearly indicate the mapping between SRIs and TRPs no matter CB or NCB operation, (4) easily and intuitively configure the mapping between SRI and power control parameters of PUSCH with low spec impact, and (5) guarantee the specs to be legibility and make the spec effort as ease as possible. |
| Ericsson | Our current preference is Option1 and Option 1 – Alt 1 for Proposal 3.1-A.  For Proposal 3.1-B, we prefer Option1 and Option 1.  For other options in the two proposals, there will be significant specification effort needed (e.g., new tables to replace Table 7.3.1.1.2-32/32A/32B in 38.212, new tables to replace Table 7.3.1.1.2-28/29/30/31 in 38.212, etc). |
| NEC | We support Option 1 –Alt 1 for Proposal 3.1-A, and Option 2 for Proposal 3.1-B  While in our opinion, there seems an issue which can be discussed firstly, which is the details of the two SRS resource sets, including **the number of SRS resources in each SRS resource set, and the number of SRS ports of each SRS resource** for codebook based transmission.  It seems some assumptions are that the number of SRS resources should be same in the two SRS resource sets, while in our opinion, the restriction seems not necessary.  And in previous agreements, the number of SRS ports between two TRPs should be same, in our understanding, here “same” is to restrict the SRS ports of the selected SRS resources for two TRPs, there is no need to restrict all the SRS resources in the two SRS resource sets to be same, especially in case of full power transmission mode, which is quite useful to be combined with M-TRP transmission for reliability enhancement. In this case, not any one of the SRS resources can be combined in the two SRS resource sets.  So in our opinion, introducing two SRI fields seems quite straightforward and simple, just to select SRS resource in the corresponding SRS resource set.  If not easy to move forward, maybe we can discuss the details for the two SRS resource sets firstly? |
| Spreadtrum | For Proposal 3.1-A, we are OK with Option1+Alt1.  For Proposal 3.1-B, we prefer Option2 for minimizing DCI payload size. With respect to dynamic switching between multi-TRP and single-TRP operation for NCB based PUSCH, we prefer Option1 with unified design with CB based PUSCH. |
| Samsung | Support Option 1 for both 3.1-A and 3.1-B in principle.  Besides, if UE can support M-TRP PUSCH repetition, we can consider new option for dynamic switching between sTRP PUSCH and mTRP PUSCH. Therefore, we want to suggest the Option 1 – Alt3 for dynamic switching. And also, we suggest the editorial changes for Proposal 3.1-A and B as follows:  **Proposal 3.1-A:** For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,   * Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.   + **Option 1: Two SRIs are indicated by two SRI fields and** ~~E~~each SRI field ~~indicating~~ **indicates** SRI per TRP, where the SRI field based on Rel-15/16 framework   + **Option 2**: two SRIs are indicated by one enhanced SRI field     - FFS: details of enhanced SRI field including the specification effort to replace Table 7.3.1.1.2-32/32A/32B in 38.212. * Support dynamic switching between multi-TRP and single-TRP operation   + **For Option 1 - Alt1:** by using two SRI fields at least when there is a reserved entry for one SRI field.     - FFS: whether to support dynamic switching if the SRI fields does not have a reserved entry   + **For Option 1 - Alt2 :** by using two SRI fields or TPMI field(s).     - FFS: Additional details of SRI/TPMI field interpretations   + **For Option 1 - Alt3 :** whether the number of SRI fields in a DCI is 1 or 2.     - If one SRI field is indicated in DCI, UE transmits PUSCH into sTRP. If two SRI fields are indicated in DCI, UE transmits PUSCH into mTRP     - FFS: how to decide the number of SRI fields in DCI formats 0\_1/0\_2 (e.g. MAC CE,…)   + **For Option 2:** by using one enhanced SRI field or TPMI field(s).     - FFS: Additional details of SRI field interpretations   **Proposal 3.1-B:** For single DCI based M-TRP PUSCH repetition schemes, in non-codebook based PUSCH,   * Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.   + **Option 1: Two SRIs are indicated by two SRI fields and ~~E~~**each SRI field ~~indicating~~ indicates SRI per TRP, where the SRI field based on Rel-15/16 framework   + **Option 2: Two SRIs are indicated by two SRI fields and ~~E~~**each SRI field ~~indicating~~ indicates SRI per TRP, where the first SRI field based on Rel-15/16 framework,     - FFS: details of second SRI field including the specification change for Table 7.3.1.1.2-28/29/30/31 in 38.212.   + **Option 3**: One enhanced SRI field indicating two SRIs     - FFS: details of enhanced SRI field including the specification effort to replace Table 7.3.1.1.2-28/29/30/31 in 38.212. * Support dynamic switching between multi-TRP and single-TRP operation   + **For Option 1 - Alt1:** by using two SRI fields at least when there is a reserved entry for one SRI field.     - FFS: whether to support dynamic switching if the SRI fields does not have a reserved entry   + **For Option 1 - Alt2:** by using two SRI fields     - FFS: Additional details of SRI field interpretations   + **For Option 1 - Alt3 :** whether the number of SRI fields in a DCI is 1 or 2.     - If one SRI field is indicated in DCI, UE transmits PUSCH into sTRP. If two SRI fields are indicated in DCI, UE transmits PUSCH into mTRP     - FFS: how to decide the number of SRI fields in DCI formats 0\_1/0\_2 (e.g. MAC CE,…)   + **For Option 2:** by using one enhanced SRI field.     - FFS: Additional details of SRI field interpretations |
| Apple | For proposal 3.1-A, we are OK for both option 1-Alt1 and option 1-Alt2.  For proposal 3.1-B, we are OK for both option 1 and option 2.  We acknowledge that joint coding should be with lowest overhead. The best way is to perform joint coding for all DCI fields if our target is overhead only. When designing signaling, we think we should consider forward compatibility. If joint coding cannot save overhead too much, separate coding should be much better. |
| vivo | We support a single enhanced SRI field for both CB and NCB(**Option2**).   * + - * Firstly, we want to confirm that switching the order of SRIs is necessary or not.   We see benefits of dynamic TRP ordering switching. We can recall that it has been supported in Rel-16 MTRP PDSCH by configuring two TCI codepoint with swapping TCI state pairs. For UL, TRP (SRI) ordering switching is also beneficial for scheduling flexibility. Examples are given below:  The beam of the first TRP may not always be available for the first PUSCH repetition transmission. As show in the following figure, when gNB scheduling a URLLC data packet starting at slot n, the indicated beam of TRP1 in slot n is unavailable. In this case, the first repetition can be scheduled to transmit towards the second TRP instead of waiting for the first beam to be valid to reduce the transmission latency.    On the other hand, for the perspective of NW scheduling multiple UE, dynamic switching the order of TRPs is also beneficial. As shown in the following figure, TRP\_x is configured for UE1 as the first TRP while it is also configured for UE2 as the second TRP. If cyclic beam mapping pattern is configured for both UE1 and UE2, and same RX beam1 is required for TRP\_x to receive certain PUSCH repetitions from UE1 and UE2. In a), RX beam1 of TRP\_x will be occupied until the end of last PUSCH repetition, i.e., from slot n to n+3, because the TRP\_x has to receive the PUSCH repetitions from two UEs alternatively in different slots. Under this circumstance, TRP\_x cannot schedule a third UE with other Rx beams in any slots from n to n+3. If the scheduling DCI of UE2 dynamically indicates that TRP\_x is the first TRP that the first PUSCH repetition targeting to, TRP\_x is available to schedule other UEs at slot n+1 and n+3, which is shown in b).    a)    b)  Unfortunately, we can’t find a solution for Options to support dynamic TRP ordering switching. While it can be indicated by the single SRI field in Option 2.   * + - * Table structure with single SRI   For SRI Table, Option 2 is also easy to implement with a field. For example, we can set up a new table between two SRIs and the combinatorial SRI by certain formulas. Details can be FFS. On the contrary, we still see difficulties in constructing the second table in Option 2.  Based on the above elaboration, we still prefer to modify the proposal as  **Proposal 3.1-A:** For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,   * Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.   + **Option 1:** Each SRI field indicating SRI per TRP, where the SRI field based on Rel-15/16 framework   + **Option 2**: One enhanced SRI field indicating two SRIs     - FFS: details of enhanced SRI field including the specification effort to replace Table 7.3.1.1.2-32/32A/32B in 38.212. * Support dynamic switching between multi-TRP and single-TRP operation   + **For Option 1 - Alt1:** by using two SRI fields at least when there is a reserved entry for one SRI field.     - FFS: whether to support dynamic switching if the SRI fields does not have a reserved entry   + **For Option 1 - Alt2 :** by using two SRI fields or TPMI field(s).     - FFS: Additional details of SRI/TPMI field interpretations   + **For Option 2:** by using one enhanced SRI field or TPMI field(s).     - FFS: Additional details of SRI field interpretations * Support dynamic switching the order of two TRPs.   **Proposal 3.1-B:** For single DCI based M-TRP PUSCH repetition schemes, in non-codebook based PUSCH,   * Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.   + **Option 1:** Each SRI field indicating SRI per TRP, where the SRI field based on Rel-15/16 framework   + **Option 2:** Each SRI field indicating SRI per TRP, where the first SRI field based on Rel-15/16 framework,     - FFS: details of second SRI field including the specification change for Table 7.3.1.1.2-28/29/30/31 in 38.212.   + **Option 3**: One enhanced SRI field indicating two SRIs     - FFS: details of enhanced SRI field including the specification effort to replace Table 7.3.1.1.2-28/29/30/31 in 38.212. * Support dynamic switching between multi-TRP and single-TRP operation   + **For Option 1:** by using two SRI fields at least when there is a reserved entry for one SRI field.     - FFS: whether to support dynamic switching if the SRI fields does not have a reserved entry   + **For Option 2:** by using two SRI fields     - FFS: Additional details of SRI field interpretations   + **For Option 3:** by using one enhanced SRI field.     - FFS: Additional details of SRI field interpretations * Support dynamic switching the order of two TRPs. |
| Nokia | For proposal 3.1-A, we support for option 1-Alt1.  For proposal 3.1-B, we support for option 1. |
| NTT Docomo | For proposal 3.1-A   * we support option1. * For dynamic switching, we prefer Alt.2. We think dynamic switching should be supported and whether there is or is not reserved entry.   For proposal 3.1-B   * we prefer option1. It is simplest design to reuse Rel-15/16 table. * For dynamic switching, we prefer option2. Similar as CB, we think dynamic switching should be supported whether there is or is not reserved entry. And a unified signaling design for CB and NCB should be considered. |
| QC | **Proposal 3.1-A**: We support **Option 1** and **Option 1 – Alt1**  **Proposal 3.1-B**: We support **Option 1** (can also accept Option 2) for both bullets.  Share similar view as other companies that joint coding while obviously has lower overhead, the aspects related to the specification impact including some very large tables / complicated formulas to be agreed upon should be also considered.  If we really want to optimize by using joint coding, we have to also consider Repetition Type A versus Repetition Type B separately (in addition to considering CB-based and NCB-based separately). This is because:   * Whether Repetition Type A or Repetition Type B is RRC configured per DCI format (not dynamic) * For Repetition Type A, max number of layers is 1. At the same time   + Single-TRP with one repetition and multi-TRP can be switched dynamically   + There is no rank limitation for single-TRP but only one SRI is needed (larger SRI bitwidth)   + For multi-TRP, two SRIs are needed, but each with smaller number of possibilities due to rank limitation * As a result, with joint coding, we can optimize even further for Repetition Type A   Generally, we do not like to make specification more complicated. However, **if down-selection to reasonable options (from spec impact point of view) is not achieved**, we suggest to also add the following for the case of non-codebook based (Proposal 3.1-B) and codebook-based (Proposal 3.3 below):  FFS: Minimizing the DCI overhead for Repetition Type A as a result of number of layers being limited to 1 when more than one repetition is scheduled. |
| CMCC | For Proposal 3.1-A,   * We support Option 1. * For dynamic switching, we support option 1-Alt 2. Because we think dynamic switching should always be supported whether or not the SRI fields have a reserved entry. It’s both fine to enhance or reinterpret the two SRI or TPMI field(s) for Alt 2.   For Proposal 3.1-B,   * We support Option 2. * For dynamic switching, we support Option 2. To reduce the DCI overhead, the second SRI field could be well redesigned based on the rank restriction between the two SRI fields. |
| OPPO | For proposal 3.1-A, we prefer Option1-Alt 1.  For proposal 3.1-B, we support Option 2 since RI is indicated in the first SRI field and same number of layers is expected for two TRPs. |
| ZTE2 | Regarding CB-related Proposal 3.1-A, due to DCI overhead should simultaneously consider SRI and TPMI, we have elaborated above the solution for indicating STRP/MTRP dynamic switching via 2nd TPMI field (Option 1 - Alt2). Please note that SRI for CB PUSCH only used for SRS selection, it is benefit to design two SRI fields based on Rel-15/16 for minimizing DCI overhead and spec legibility, where the configured mappings between SRI and PC parameters are very clear.  Regarding NCB-related Proposal 3.1-B, some companies held the view that unified design should be used for both CB and NCB PUSCH. From the perspective of rank indication and SRI’s functionality in Rel-15/16 for CB and NCB PUSCH, due to TPMI used for CB PUSCH as well as SRI used for NCB PUSCH, it makes sense to use unified framework for rank indication to adopt Option 2, instead of **Option 1 which is just literal unified design rather than technical**. Although some companies have concern of spec effort, Option 2 can be easily captured in specs compared with Option 3. Generally speaking, 3GPP aims to solve every issue technically even if few spec effort needed. Here, some corrections should be made as follows for clarification of Option 2.  **Proposal 3.1-B:** For single DCI based M-TRP PUSCH repetition schemes, in non-codebook based PUSCH,   * Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.   + **Option 1:** Each SRI field indicating SRI per TRP, where the SRI field based on Rel-15/16 framework   + **Option 2:** Each SRI field indicating SRI per TRP, where the first SRI field based on Rel-15/16 framework, the second SRI field dose not indicates the number of layers.     - FFS: details of second SRI field including the specification change for Table 7.3.1.1.2-28/29/30/31 in 38.212.   + **Option 3**: One enhanced SRI field indicating two SRIs     - FFS: details of enhanced SRI field including the specification effort to replace Table 7.3.1.1.2-28/29/30/31 in 38.212. * Support dynamic switching between multi-TRP and single-TRP operation   + **For Option 1:** by using two SRI fields at least when there is a reserved entry for one SRI field.     - FFS: whether to support dynamic switching if the SRI fields does not have a reserved entry   + **For Option 2:** by using one or two SRI field(s)     - FFS: Additional details of SRI field(s) interpretations   + **For Option 3:** by using one enhanced SRI field.     - FFS: Additional details of SRI field interpretations |
| Huawei, HiSilicon | For codebook based PUSCH, we support option 2, regarding the DCI overhead and benefits of dynamic switching of order of repetition mentioned by Vivo. In addition, we don’t think the spec impact for option 2 would be very large, as for CB based PUSCH, SRI is just to indicate the SRS resource instead of layers etc. for NCB based PUSCH. Anyway, as discussed in proposal 3.3, new tables for TPMI of CB based PUSCH is needed.  For NCB based PUSCH, we support option 2. In last meeting, we have agreed to have the same rank for CB, and it can also be used for NCB to reduce DCI overhead. |
| CATT | For Proposal 3.1-A, we support Option 1 - Alt2  For Proposal 3.1-B, we support Option 2. |
| FL update #1 | Each comment and side have valid inputs. It is clear that few companies are having different views than majority.  I am addressing few comments on proposals and alternatives listed above.  **LG**>> your table copied to your comment box to avoid mixing things.  **SS** >> I would not generalize option 1 in proposal 3.1 – A as that is majority view. I do not think the proposal you have below is accurate.  ***For Option 1 - Alt3 :*** *whether the number of SRI fields in a DCI is 1 or 2.*   * *If one SRI field is indicated in DCI, UE transmits PUSCH into sTRP. If two SRI fields are indicated in DCI, UE transmits PUSCH into mTRP* * *FFS: how to decide the number of SRI fields in DCI formats 0\_1/0\_2 (e.g. MAC CE,…)*   In general, RRC configures the fields of DCI and there should be either one or two fields. It seems that your thinking is different here. Please clarify how this actually work if that is to include as alternative. A similar comment is valid for the option suggested in Proposal 3.1-B.  **vivo** >> you suggested to include “*Support dynamic switching the order of two TRPs*”. But, this can not be in the main bullet as that is not the majority view. It could be addressed within option 2 that you support where lot of details are FFS.  **Spreadtrum, DCM** >> you commented that support option 2 for dynamic switching in proposal 3.1-B. what do you have in mind as you also support option 1 which means two SRI field as legacy. May be something to clarify. Do you have the same proposal in mind as option 1.  **QC** >> FFS you suggested is added.  **ZTE**>> your suggestions are considered in the update.  **All**>> latest version based on QC/ZTE suggestion can be found in the proposals. Add your support each proposal. Nothing much we can do other than going into online session.  For now, FL thinks the following should be the way forward,  **Proposal 3.1-A:** For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,   * Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.   + **Option 1:** Each SRI field indicating SRI per TRP, where the SRI field based on Rel-15/16 framework * Support dynamic switching between multi-TRP and single-TRP operation   + **For Option 1 - Alt1:** by using two SRI fields at least when there is a reserved entry for one SRI field.     - FFS: whether to support dynamic switching if the SRI fields does not have a reserved entry   **Proposal 3.1-B:** For single DCI based M-TRP PUSCH repetition schemes, in non-codebook based PUSCH,   * Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.   + **Option 2:** Each SRI field indicating SRI per TRP, where the first SRI field based on Rel-15/16 framework, the second SRI field does not indicate the number of layers     - FFS: details of second SRI field including the specification change for Table 7.3.1.1.2-28/29/30/31 in 38.212. * Support dynamic switching between multi-TRP and single-TRP operation   + **For Option 2:** by using one or two SRI field(s)     - FFS: Additional details of SRI field(s) interpretations * FFS: Minimizing the DCI overhead for PUSCH repetition DG based only Type A as a result of number of layers being limited to 1 when more than one repetition is scheduled. |
| InterDigital | For Proposal 3.1-A, we support Option 1, and Option 1 – Alt1. For Proposal 3.1-B, we support Option 1, and Option 1. |
| Futurewei | Support the FL’s updated proposal 3.1-A, though we are also ok with Option 2.  Support the FL’s updated proposal 3.1-B. |
| Intel | For 3.1-A,  option-1 – alt-1 is not a complete solution, doesn’t allow re-ordering of SRS resource sets  option-1- alt-2 and option 2 – we need to check further details in order to consider specification impact.  For 3.1-B, similar situation that option 1 is not complete and doesn’t allow re-ordering of SRS resource sets while option 2 and 3 needs additional details to be studied.  we think further discussion and study is need to down-select |
| ZTE3 | We have strong concern and technical consideration of CB-related Proposal 3.1-A.  From the technical prospective, it is critical to minimize DCI overhead for single-DCI based MTRP PUSCH. For CB PUSCH, due to both TPMI and SRI indications are needed, **it makes sense to consider DCI overhead of both TPMI fields and SRI fields**. Comparing Option 1-Alt1 with Option1-Alt2, SRI fields are always needed for Alt1, but Alt2 is not. One intuitive example, only one SRS in each SRS resource set for STRP operation, Alt1 always needs at least 1bit of SRI fields to indicate SRS set/TRP selection, meanwhile Alt2 does not need SRI fields due to 2nd TPMI field is used to indicate this selection.  Besides, **unified design of STRPMTRP dynamic switching should based on technical driven instead of literal likeness**. With respect to rank indication in Rel-15/16, due to TPMI is used for CB PUSCH and SRI is used for NCB PUSCH, consequently option 1-Alt2 in Proposal 3.1-A for CB PUSCH is unified with option 2 in Proposal 3.1-B for NCB PUSCH. Based on that, the indications of rank and STRP/MTRP dynamic switching for CB and NCB based MTRP PUSCH is aligned.  For the sake of progress with technical consideration, we suggest:  **Proposal 3.1-A:** For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,   * Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.   + **Option 1:** Each SRI field indicating SRI per TRP, where the SRI field based on Rel-15/16 framework * Support dynamic switching between multi-TRP and single-TRP operation   + FFS: by using two SRI fields or TPMI field(s) at least when there is a reserved entry for one SRI or TPMI field, further discuss whether to support dynamic switching if the SRI fields does not have a reserved entry and the addition detail of SRI/TPMI field interpretations. |
| NTT Docomo2 | We would like to clarify our understanding of option1-alt.1 in proposal 3.1A and option1-option1 in proposal 3.1B.  In case the SRI field has no reserved entry, by using two SRI fields for dynamic switching, does it mean new entries can be introduced in addition to Rel-15/16 entries, otherwise, how to support dynamic switching by using two SRI fields when there is no reserved entry? |
| Xiaomi | Support the updated proposal 3.1 A, also we have the same concern that if further extension is needed when cases that SRI without a reserved codepoint to support the dynamic switching.  For 3.2B, we agree in principle |
| FL update #2 | Intel >> based on FL understanding, SRS resource set reordering is not considered essential by the majority. Since RV and beam patterns allows some flexibility, FL assumes this is not a critical thing.  ZTE >> RAN1 shall move forward and FL assume the situation is clear with the supporting companies. It is not recommended to wait for design details as there are many other details are still to be discussed on beam mapping after RAN4 LS is received. .  DCM, Xiaomi >> no additional entry. If there are no reserved entry, FL assume the default solution would be no dynamic switching in that case. Tried to capture that in the updated proposal.  **Proposal 3.1-A:** For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,   * Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.   + **Option 1:** Each SRI field indicating SRI per TRP, where the SRI field based on Rel-15/16 framework * Support dynamic switching between multi-TRP and single-TRP operation   + **For Option 1 - Alt1:** by using two SRI fields at least when there is a reserved entry for one SRI field.     - When the SRI fields does not have a reserved entry, the dynamic switching cannot be supported.     - FFS: whether to support dynamic switching if the SRI fields does not have a reserved entry   Intel, ZTE have concerns  **Proposal 3.1-B:** For single DCI based M-TRP PUSCH repetition schemes, in non-codebook based PUSCH,   * Support two SRIs corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.   + **Option 2:** Each SRI field indicating SRI per TRP, where the first SRI field based on Rel-15/16 framework, the second SRI field does not indicate the number of layers     - FFS: details of second SRI field including the specification change for Table 7.3.1.1.2-28/29/30/31 in 38.212. * Support dynamic switching between multi-TRP and single-TRP operation   + **For Option 2:** by using one or two SRI field(s)     - FFS: Additional details of SRI field(s) interpretations * FFS: Minimizing the DCI overhead for PUSCH repetition Type A as a result of number of layers being limited to 1 when more than one repetition is scheduled.   Intel has concerns |

### Proposal 3.3

**Proposal 3.3:** For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,

* **Option 1**: two TPMI fields are indicated in DCI formats 0\_1/0\_2.
  + **Alt.1** : The first TPMI field uses the Rel-15/16 TPMI field design (which includes TPMI index and the number of layers) of DCI format 0\_1/0\_2. The second TPMI field only indicates the second TPMI index. The same number of layers are applied as indicated in the first TPMI field.
    - FFS: Details of second TPMI field interpretation including changes expected in Tables 7.3.1.1.2-2/2A/2B/3/3A/4/4A/5/5A in 38.212
  + **Alt.2** : The first and second TPMI fields use the Rel-15/16 TPMI field design (which includes TPMI index and the number of layers) of DCI format 0\_1/0\_2.
* **Option 2**: enhanced TPMI field is indicated in DCI formats 0\_1/0\_2.
  + The enhanced TPMI field indicates first TPMI index, second TPMI index, and the number of layers. The same number of layers are applied for both TPMI indexes.
    - FFS: Details of TPMI field interpretation including the specification effort to replace Tables 7.3.1.1.2-2/2A/2B/3/3A/4/4A/5/5A in 38.212

This discussion is copied from Phase #2, and please see the bottom of the table for the FL update.

|  |  |
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| **Company** | **Comments** |
| LG | Considering the large number of codepoints in conventional TPMI field, we are fine with Option 1 and Alt 1. |
| ZTE | Support Option 1 - Alt1. |
| Ericsson | Support Option 1 – Alt2. |
| NEC | Support Option 1 - Alt.1 |
| Spreadtrum | We are fine with Option1-Alt1. |
| Samsung | Support Option 1 - Alt. 2 (simplest design. We can reuse Rel-15/16 TPMI table instead of new complicated table). |
| Apple | We are fine with option 1, either Alt1 or Alt2 is ok. |
| vivo | Support Option 2 and a single TPMI shared for PUSCH repetitions towards different TRPs.   * + - * **Shared TPMI indicated by a TPMI field for PUSCH repetitions towards two TRPs**   Besides, a single TPMI field indicating one shared TPMI between the PUSCH repetitions towards different TRPs should be supported as well to reduce DCI overhead, at lease in FR1. Actually, through thorough evaluation on performance of PUSCH repetitions sharing one TPMI and using two separate TPMIs in FR1, in which joint detection of multi-TRPs can be implemented. Received signals are combined in antenna domain and then decoding them as a large distributed antenna array. We observed that the performance of PUSCH repetitions sharing one TPMI is close to PUSCH repetitions using separate TPMIs. To further reduce DCI overhead, one shared TPMI using Rel-15/16 framework for PUSCH transmission towards two TRPs can be supported at least in FR1.    Performance of PUSCH repetitions under joint or separate detection with shared or separate TPMIs.   * + - * **Benefits of Option 2**   Compared to Option1, Option2 can save 1bit in some cases listed in the following table. So, we have preference on Option2 from perspective of DCI overhead.      The new TMPI tables can also be set up a new TPMI table between two TPMIs and the combinatorial TPMI by certain formulas.   * + - * **Further overhead reduction**   For both options, the bit width of the TPMI field(s) can be further reduced. Take Option 1 for example, the bit width of the second TPMI can be reduced by further limiting the coherent codebook subset through MAC CE. Assuming the codebook subset is configured with 'fullyAndPartialAndNonCoherent', gNB often select fully coherent codebook to take full advantage of Tx diversity, unless gNB detects that the wireless channel quality of some antenna ports of SRS resource is poor, e.g. when antenna ports are blocked by hands or other objects, in which case a codebook with the feature of partial coherent or non-coherent may be indicated by TPMI field in DCI to save UE power consumption. To respectively inform the coherence, the second field can save another 1bit at least.  Hence, we propose to modify the proposal as:  **Proposal 3.3:** For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,   * **Option 1**: two TPMI fields are indicated in DCI formats 0\_1/0\_2.   + **Alt.1** : The first TPMI field uses the Rel-15/16 TPMI field design (which includes TPMI index and the number of layers) of DCI format 0\_1/0\_2. The second TPMI field only indicates the second TPMI index. The same number of layers are applied as indicated in the first TPMI field.     - FFS: Details of second TPMI field interpretation including changes expected in Tables 7.3.1.1.2-2/2A/2B/3/3A/4/4A/5/5A in 38.212   + **Alt.2** : The first and second TPMI fields use the Rel-15/16 TPMI field design (which includes TPMI index and the number of layers) of DCI format 0\_1/0\_2. * **Option 2**: enhanced TPMI field is indicated in DCI formats 0\_1/0\_2.   + The enhanced TPMI field indicates first TPMI index, second TPMI index, and the number of layers. The same number of layers are applied for both TPMI indexes.     - FFS: Details of TPMI field interpretation including the specification effort to replace Tables 7.3.1.1.2-2/2A/2B/3/3A/4/4A/5/5A in 38.212 * **Option 3**: Support PUSCH repetitions transmitting towards two TRPs sharing the same TPMI indicated by a TPMI field designed in Rel-15/16. * FFS: further overhead reduction methods, such as overhead of the second TPMI field. |
| Nokia | Support Option 1 - Alt.1 |
| NTT Docomo | We support option1. And prefer alt.2. It is simplest design to reuse R15/16 table. |
| QC | Option 1 – Alt1. |
| CMCC | Support Option 1 - Alt.1 |
| OPPO | Support Option1-Alt1. |
| ZTE2 | @Samsung, E///, DOCOMO>> please note simplest way does not means useful and technical design. For single-DCI based MTRP CB PUSCH, it was agree that the number of layers of two TRPs/SRS resource sets should be same. Based on that, it makes no sense to indicate same layers value twice by 2nd TPMI because that will lead to the wasting of overhead.  Besides, option 2(one single TPMI design) is the worst solution, due to it will cause pretty huge spec efforts, such as 4-Tx and maxRank 4 based PUSCH, and which also make a poor readability for spec. Shall the proponent of option 2 show us how to edit the single TPMI field in Tables 7.3.1.1.2-2/2A/2B/3/3A/4/4A/5/5A in 38.212? Specially, up to 1404 candidates needed to be included for the case of 4-Tx and maxRank 4 based PUSCH. |
| Huawei, HiSilicon | Support Option 1-Alt 1. |
| CATT | Support Option 1 - Alt1. |
| FL update #1 | Company support showed in the proposal.  **Vivo** >> you are supporting option 2 and proposing another option (option 3) to add. You could suggest which one you like the most to keep that, also text provided for option 3 is not clear. Also, FFS added is not matching as a general statement.  There is clear majority on option alt. 1.  **Proposal 3.3:** For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,   * **Option 1**: two TPMI fields are indicated in DCI formats 0\_1/0\_2.   + **Alt.1** : The first TPMI field uses the Rel-15/16 TPMI field design (which includes TPMI index and the number of layers) of DCI format 0\_1/0\_2. The second TPMI field only indicates the second TPMI index. The same number of layers are applied as indicated in the first TPMI field. |
| InterDigital | We support Option 1 with either option. |
| Futurewei | Support the FL’s proposal. |
| Intel | It is clear that option-1, alt-2 is the most inefficient but it is not clear how option-1-alt-1 compares to option-2 in terms of performance/specification impact. We are okay to down-select to Option-1, Alt-1 and option 2 in this meeting. |
| Xiaomi | Support Option 1 - Alt.1 |
| FL update #2 | Proposal 3.3. is kept as the majority seems ok with it.  **Proposal 3.3:** For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,   * **Option 1**: two TPMI fields are indicated in DCI formats 0\_1/0\_2.   + **Alt.1** : The first TPMI field uses the Rel-15/16 TPMI field design (which includes TPMI index and the number of layers) of DCI format 0\_1/0\_2. The second TPMI field only indicates the second TPMI index. The same number of layers are applied as indicated in the first TPMI field. |

# Phase #3 proposals

Several companies highlighted high-priority proposals that they would like to discuss. Few suggestions are considered below.

**Proposal 1:** For s-DCI based multi-TRP PUSCH repetition Type A and B, if the DCI schedules aperiodic CSI, support multiplexing A-CSI on the first PUSCH repetitions corresponding to two beams.

* For PUSCH repetition Type B, the UE does not expect the first actual repetitions corresponding to two beams to have a single symbol duration (similar restriction as in Rel-16 NR for the single TRP case).
  + FFS: whether first actual repetitions corresponding to two beams are expected to have the same number of symbols
* FFS: Any further restrictions/enhancements needed on supporting A-CSI multiplexing on PUSCH repetitions

Please add comments below.

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| --- | --- |
| Company | Comments |
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|  |  |

**Proposal 2:** Further study following aspects related to beam mapping and default behaviors for multi-TRP PUCCH/PUSCH schemes,

* Whether enhancements needed on beam mapping in case of PUCCH/PUSCH dropping due to invalid UL symbols
* Whether frequency hopping is performed among the repetitions with the same beam
* Whether defining default beam for PUSCH is needed when PUSCH scheduled by DCI format 0\_0 when two spatial relation info’s are configured for a PUCCH resource

Please add comments below.

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| Company | Comments |
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# Agreements

**Agreement**

For single DCI based M-TRP PUSCH repetition Type B, support the following RV mapping,

* DCI indicates the first RV for the first PUSCH actual repetition, and the RV pattern (0 2 3 1) is applied separately to PUSCH actual repetitions of different TRPs with a possibility of configuring RV offset for the starting RV for the first actual repetition towards second TRP (The same method as PDSCH scheme 4).

**Agreement**

Support CG PUSCH transmission towards M-TRPs using a single CG configuration.

* Use same beam mapping principals as dynamic grant PUSCH repetition scheme.
* FFS: Required changes on CG parameters (ConfiguredGrantConfig)

The feature is UE optional

**Agreement**

For M-TRP PUCCH scheme 1,

* Support PUCCH formats 0 and 2 (in addition to agreed PUCCH formats 1,3,4)

**Agreement**

For M-TRP PUCCH scheme 1,

* For PUCCH formats 1/3/4, values for the total number of repetitions at least contain values 2, 4, and 8.
  + FFS: maximum repetition number can be extended to 16.
* For PUCCH formats 0/2, the total number of repetitions at least contain 2.
  + FFS: other values.
* RRC configured number of slots (repetitions) are applied across both TRPs (e.g if the number of repetitions given by *nrofSlots* in *PUCCH-config* is 8, per TRP limit is 4).

**Agreement**

To support per TRP power control for multi-TRP PUCCH schemes in FR1,

* Two sets of power control parameters are used, and each set has a dedicated value of p0, pathloss RS ID and a closed-loop index.
* FFS: details on how a PUCCH resource can be linked to one or both of the two sets of power control parameters.
* FFS: whether PUCCH resource group can be linked to power control parameter sets.

**Agreement**

For single-DCI based M-TRP PUSCH repetition schemes, up to two power control parameter sets (using *SRI-PUSCH-PowerControl*) can be applied when SRS resources from two SRS resource sets indicated in DCI format 0\_1/0\_2.

* FFS1: Details on linking SRI fields to two power control parameters,
  + Alt. 1: Add second *sri-PUSCH-MappingToAddModList,* andselect two *SRI-PUSCH-PowerControl* from two *sri-PUSCH-MappingToAddModList*
  + Alt. 2: Add SRS resource set ID in *SRI-PUSCH-PowerControl,* and select *SRI-PUSCH-PowerControl* from *sri-PUSCH-MappingToAddModList* considering the SRS resource set ID
  + Alt. 3: Let RAN2 handle this
  + Alt.4: Add second *sri-PUSCH-PathlossReferenceRS-Id/sri-P0-PUSCH-AlphaSetId/sri-PUSCH-ClosedLoopIndex* in *SRI-PUSCH-PowerControl*.
* FFS2: Enhancements on open-loop power control parameter set indication
* FFS3: Consideration on *srs-PowerControlAdjustmentStates*
* FFS4: Impact of multi-TRP PUSCH repetition on PHR reporting
* FFS5: Enhancement on power control parameters per TRP when SRI(s) indication of two SRS resource sets is absent.

**Working Assumption**

For PUCCH reliability enhancement, support multi-TRP intra-slot repetition (Scheme 3) for all PUCCH formats.

* The same PUCCH resource carrying UCI is repeated for X = 2 [consecutive] sub-slots within a slot.
* Refer the design details related to sub-slot configurations (e.g. other values of X) to Rel-17 eIIoT

Note1: The decision of supporting scheme 3 is only applicable for multi-TRP operation.

**Conclusion**

For Multi-TRP PUCCH Scheme 1/3 at least containing HARQ ACK, supporting dynamic switching between multi-TRP PUCCH scheme and single-TRP PUCCH transmission is not restricted, and can be done by associating,

* a PUCCH resource activated with one or two spatial-relation-info and PRI bit-field indicating a PUCCH resource,
* or a PUCCH resource with one or two power control parameter sets and PRI bit-field indicating a PUCCH resource

FFS: Support of dynamic switching for Scheme 2 (if the schemes supported)