3GPP TSG RAN WG1 #105-e R1-200xxxx

e-Meeting, May 19th – May 27th, 2021

**Agenda item: 8.1.2.1**

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

**Title: Summary #2 of Multi-TRP PUCCH and PUSCH Enhancements**

**Document for: Discussion and Decision**

# Introduction

This is the phase 1 discussion of M-TRP PUSCH and PUCCH enhancement for Rel-17. Previous FL summary version can be found in R1-2106073 and v062 of the draft folder.

R1-2106073 Summary#1 of Multi-TRP for PUCCH and PUSCH Moderator (Nokia)

Latest proposals are in yellow.

FL update is in blue.

Offline agreement purple.

# Multi-TRP PUCCH transmission

## 2.1 Offline agreements from Phase 0

**Offline agreement 2.3:** For multi-TRP PUCCH (scheme 1 and 3) and PUSCH (Type A and B) repetition, when the number of repetitions is equal to two, the first and second transmission occasion shall be associated with two TRPs, respectively (two UL beams or Power control parameter sets), regardless of the configured mapping pattern.

• Note: For M-TRP PUSCH type B, the number of repetitions refers to ‘nominal’ repetition.

## 2.1 Continued discussion from Phase 0

### Proposal 2.1: Power control TPC

**Proposal 2.1:**

* To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2, a second TPC field can be configured via RRC.
* When the second field is configured by RRC , a second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2 (option 3).
* When the second field is not configured by RRC ,  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.
* To support per TRP closed-loop power control for PUSCH with DCI formats 0\_1 / 0\_2, adopt the same solution as with M-TRP PUCCH schemes.
* Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs. This does not have ~~to~~ any relation to the RRC parameter ~~defining the DCI field size~~ indicating the presence of the second TPC field.
* Note2: UE capability related to the above can be discussed in the UE feature discussions.
* FFS: whether to use two TPC fields to indicate one shared TPC value of TRPs when the “closedLoopIndex” values are the same for TRPs.

Please provide your concerns (if any). Please check [v062](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/8.1.2.1/Round%200/Draft_FL_Summary_M-TRP_PUCCH_PUSCH_v062_Mod_vivo5.docx) for old discussions (removed to improve the readability of the FL summary).

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| Company | Comments |
| CATT | After further check, we are a little confused on the meaning of “This does not have ~~to~~ any relation to the RRC parameter ~~defining the DCI field size~~ indicating the presence of the second TPC field”. It includes the scenario that when the “closedLoopIndex” values are the same for TRPs, the second TPC field can be configured via RRC? In our opinion, the second TPC filed can only be configured when the “closedLoopIndex” values are different for TRPs since “Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs” and the second TPC filed is configured “To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2”.  We suggest to update Note 1 of FL’s proposal:   * Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs. ~~This does not have to any relation to the RRC parameter defining the DCI field size indicating the presence of the second TPC field.~~ When the “closedLoopIndex” values are not the same for TRPs, the RRC parameter indicating the presence of the second TPC filed can be configured or not. |
| NTT Docomo | Support the proposal. |
| QC | Support the proposal. Regarding the FFS, we think it is not relevant as the whole issue under discussion is when closedloopIndex values are not the same. Nevertheless, since it is FFS, we can accept it. |
| Ericsson | We have similar questions as CATT and QC regarding when this per-TRP power control is applicable. In our view, the newly added FFS is not needed, since for multi-TRP PUSCH/PUCCH, we will need to configure two different closed-loop indices. So we suggest to remove the newly added FFS. Also, ‘This does not have ~~to~~ any relation to the RRC parameter ~~defining the DCI field size~~ indicating the presence of the second TPC field.’ doesn’t seem to be needed and can be removed. Since we already compromised to accept Option 1 in place of Option 4, we’d like these additions FFSs removed. We can support the following version.  **Proposal 2.1:**   * To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2, a second TPC field can be configured via RRC. * When the second field is configured by RRC , a second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2 (option 3). * When the second field is not configured by RRC ,  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. * To support per TRP closed-loop power control for PUSCH with DCI formats 0\_1 / 0\_2, adopt the same solution as with M-TRP PUCCH schemes. * Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs. ~~This does not have to any relation to the RRC parameter defining the DCI field size indicating the presence of the second TPC field.~~ * Note2: UE capability related to the above can be discussed in the UE feature discussions. * ~~FFS: whether to use two TPC fields to indicate one shared TPC value of TRPs when the “closedLoopIndex” values are the same for TRPs.~~ |
| ZTE | We can be fine with the updated proposal, besides we do NOT support to remove the newly added FFS and “This does not have ~~to~~ any relation to the RRC parameter ~~defining the DCI field size~~ indicating the presence of the second TPC field.” in Note 1 with the following elaborations. It should be noted that RAN1 endorsed one agreement in #104-e meeting that STRP/MTRP dynamic switching for MTRP PUCCH scheme can be done by associating a PUCCH resource activated with one or two beams and PRI bit-field indicating a PUCCH resource. Based on that, one case can be true, that is, the PUCCH resource selected from one PUCCH resource set may be activated as the following three categories: (i) a single beam with a single closed loop index, or (ii) two beams with a single closed loop index, or (iii) two beams with two different closed loop indices. Accordingly, once a PUCCH resource is configured with two beams and two closed loop indices (Cat. iii) in PUCCH resource set, the second TPC field should always be present in DCI. That means the second TPC field is present in DCI or not should depend on the RRC configuration of PUCCH resource set for MTRP scheme, plus the new RRC used to indicate the second TPC field is redundant. Meanwhile, when the case of another PUCCH resource indicated by PRI field with a single closed loop index (Cat. i or Cat. ii) from the same PUCCH resource set at one time, two TPC fields are still present in DCI. In such case, how to associate the single closed loop index and two TPC fields should be clarified.  @CATT, please think again based on my explanation above, please note that the existence of the second TPC fields depends not only on different closed loop indices for TRPs, but also on the PUCCH resource set for MTRP scheme.  @Ericsson, as per your comment that “*In our view, the newly added FFS is not needed, since for multi-TRP PUSCH/PUCCH, we will need to configure two different closed-loop indices.*”, I fail to see the logical that why closed loop indices towards two TRPs cannot be the same? Although we agreed to support per TRP PUCCH PC parameter set in previous meetings, it doesn’t mean the values of such parameters (e.g. P0/Alpha, PL-RS id, closed loop index) is mandatory to be different for two TRPs. BTW, whether the values of PC parameter are same or not towards different TRPs actually depends on gNB to enable flexibility of scheduling. |
| Fujitsu | Same view as QC. |
| LG | Regarding the last FFS bullet, the issue can be simply addressed by gNB implementation such as indicating two TPC value as the same. We suggest the following revision, which may address ZTE’s concern:  **Proposal 2.1:**   * To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2, a second TPC field can be configured via RRC. * When the second field is configured by RRC , a second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2 (option 3). * When the second field is not configured by RRC ,  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. * To support per TRP closed-loop power control for PUSCH with DCI formats 0\_1 / 0\_2, adopt the same solution as with M-TRP PUCCH schemes. * Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs. This does not have ~~to~~ any relation to the RRC parameter ~~defining the DCI field size~~ indicating the presence of the second TPC field. * Note2: UE capability related to the above can be discussed in the UE feature discussions. * ~~FFS: whether to use two TPC fields to indicate one shared TPC value of TRPs when the “closedLoopIndex” values are the same for TRPs.~~ * UE expects the same TPC value for the two TPC fields when the “closedLoopIndex” values are the same for TRPs. |
| MediaTek | Support the proposal. We fail to see a use case where some PUCCH resources in a PUCCH resource set are with two different closed loop indices, but some others are with two identical closed loop indices. Besides, it suffices that the same behavior is applied across all PUCCH resource sets. Thus, the note “This does not have to any relation to the RRC parameter indicating the presence of the second TPC field” is unnecessary. Nevertheless, we are fine with either keeping it or not. |
| Apple | It seems the whole discussion is not needed. According to the spec, the TPC command is applied for the scheduled PUCCH. So it should be option 1 by default. If we want to enhance it, to re-interpret this TPC command as option 4 can provide better flexibility, but it seems no consensus does not make system broken.  - TPC command for scheduled PUCCH – 2 bits as defined in Clause 7.2.1 of [5, TS 38.213] |
| OPPO | We think the main issue locates in 2nd TPC field is configured by RRC or implicated by “closedLoopIndex” of RRC configurations. So we list all cases for TPC field and closedLoopindex. From the table, no matter the 2nd TPC field is configured by RRC or indicated from closedLoopIndex, rule is required always. So we prefer the 2nd tpc field is configured by RRC. In summary, we support FL proposal.   |  |  |  | | --- | --- | --- | | 2nd TPC field is configured by RRC irrespective of “closedLoopIndex” in RRC | 2 tpc fields in DCI | 1 tpc field in DCI | | 2 close loop indexes | MTRP：works  STRP：which tpc field should be selected （should be clarified） | MTRP：one TPC value indicated in tpc field applied in two beams  STRP： works | | 1 close loop index | NA | MTRP：one TPC value indicated in tpc field applied in two beams  STRP： works |  |  |  |  | | --- | --- | --- | | 2nd TPC field is only related with “closedLoopIndex” in RRC | 2 tpc fields in DCI | 1 tpc field in DCI | | 2 close loop indexes | MTRP： works  STRP：which tpc field should be selected （should be clarified） | NA | | 2 close loop indexes | NA | MTRP：one TPC value indicated in tpc field applied in two beams  STRP： works | |
| Lenovo&MotM | Support. |

### Proposal 2.2: Default beam for PUSCH

**Proposal 2.2:** If the PUCCH resource with the lowest ID is activated with two spatial relation info, the spatial relation info with lower ID is used as the default beam for PUSCH scheduled by DCI format 0\_0.

Please provide your concerns (if any). Please check [v062](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/8.1.2.1/Round%200/Draft_FL_Summary_M-TRP_PUCCH_PUSCH_v062_Mod_vivo5.docx) for old discussions (removed to improve the readability of the FL summary).

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| Company | Comments |
| CATT | The following revision is suggested:  **Proposal 2.2:** If the PUCCH resource with the lowest ID is activated with two spatial relation info, the spatial relation info with lower ID is used as the default beam for single-TRP PUSCH scheduled by DCI format 0\_0. |
| NTT Docomo | Support |
| QC | Support. |
| ZTE | Support |
| Fujitsu | Support |
| LG | Do not support. What is issue with limiting one spatial relation info for PUCCH resource with the lowest ID? At least one PUCCH resource with one spatial relation info is needed anyway to support dynamic switching between MTRP and STRP. |
| MediaTek | OK |
| Apple | Support |
| OPPO | Support |
| Lenovo&MotM | Support |

### Proposal 2.4: Scheme 1 – Frequency hopping and beam mapping

**Proposed Conclusion 2.4:** When inter-slot frequency hopping is configured with Scheme 1, frequency hopping is performed on slot level as in Rel-15 (no spec impact).

Please provide your concerns (if any). Please check [v062](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/8.1.2.1/Round%200/Draft_FL_Summary_M-TRP_PUCCH_PUSCH_v062_Mod_vivo5.docx) for old discussions (removed to improve the readability of the FL summary).

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| Company | Comments |
| CATT | To ensure UL performance, option 1 is still preferred. |
| NTT Docomo | Support |
| QC | We provided reasons why option 1 is beneficial. Option 1 is preferred by majority. We feel that valid enhancements are treated as if we are in the maintenance phase. |
| Ericsson | Ok. |
| ZTE | Okay. |
| Fujitsu | Prefer option 1. |
| LG | Same view with CATT and QC. |
| MediaTek | Support |
| Apple | Same view with CATT/QC/LG |
| OPPO | Support |
| Lenovo&MotM | Not support. Same view with CATT/QC/LG/Apple |

### Proposal 2.5: Intra-slot repetition (scheme 3)

Proposal 2.5: Confirm the working assumption with removing brackets on [consecutive] and adding UE capability.

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.
* This feature is optional for PUCCH format 1, 3 and 4.

Please provide your concerns (if any). Please check [v062](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/8.1.2.1/Round%200/Draft_FL_Summary_M-TRP_PUCCH_PUSCH_v062_Mod_vivo5.docx) for old discussions (removed to improve the readability of the FL summary).

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| Company | Comments |
| CATT | We fail to see the need to restrict this feature as optional for format 1,3 and 4. |
| NTT Docomo | Support |
| QC | For the last bullet, “PUCCH format 1, 3, and 4” should be removed. It does not make sense to make this feature mandatory for PUCCH formats 0 and 2. |
| Ericsson | The last bullet is not needed. In our view, the last bullet can be discussed later during UE feature discussion. |
| ZTE | Share the similar with companies that the last bullet should be removed. |
| MediaTek | Support the proposal without the last bullet. |
| Apple | Support |
| OPPO | Share the similar view that last bullet should be removed |

## 2.3 Additional discussions for Phase 1

### Issue 1: Support Scheme 2

**Question 1:** Please indicate your views on supporting Scheme 2, MTRP intra-slot PUCCH beam hopping.

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| Company | Comments |
| CATT | If scheme 3 is supported, scheme 2 seems to be redundant. |
| NTT Docomo | Share similar view with CATT. |
| QC | Support the proposal. We do not agree with the argument that Scheme 2 is redundant. Scheme 2 is much easier to implement compared with Scheme 3, as frequency hopping is replaced with beam hopping, and that’s it. Scheme 3 comes with sub-slot based configurations and all the restrictions that come with it in terms of PUCCH/PUSCH overlapping. For example, UCI multiplexing is not allowed for scheme 3 (same way that in Rel. 15, for PUCCH repetition there are strict and inflexible rules in 38.213 Section 9.2.6). Scheme 2 is not subject to those limitations. |
| Intel | Same view as CATT, DOCOMO |
| Ericsson | We do not see the need to specify Scheme2 in NR Rel-17. |
| ZTE | Scheme 2 should be supported for Rel-17 MTRP PUCCH.  It can be seen that scheme 2 aims to improve reliability and reduce latency for further enhancement. Specifically, when there are two beams activated for a PUCCH resource without repetition, the single PUCCH occasion of the given PUCCH resource is divided into two sets of symbols which corresponds to two beams. Based on that, scheme 2 can be implemented by following frequency hopping pattern in Rel-15 and directly improve the reliability of PUCCH transmission with low spec change. |
| Fujitsu | Same view as ZTE. |
| LG | Support scheme 2. Even though scheme 3 already supports intra-slot repetition, scheme 2 provides benefits of simple implementation by reusing frequency hopping framework. |
| Apple | Do not support. It is redundant feature compared to scheme 3 |
| OPPO | Share similar view with CATT and other companies that Scheme 2 is redundant. |
| Lenovo&MotM | Do not support. It is redundant feature compared to scheme 3 |

### Issue 2: PUCCH Grouping

**Question 2:** Please indicate your views on enhancement related to group based PUCCH spatial relation (updated by MAC CE) for Rel-17 MTRP PUCCH scheme

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| Company | Comments |
| QC | We are open to discuss further depending on the exact enhancements intended here. |
| Ericsson | This may not be urgent. But we are ok to further study. |
| ZTE | Support.  In Rel-16, group of PUCCH resources can be configured for spatial relation update simultaneously, and up to four PUCCH groups are supported, where each PUCCH resource group corresponds to one beam or one spatial relation. This feature is very helpful to save MAC CE overhead in FR2. So it is natural to support it for multi-TRP PUCCH transmissions in Rel-17 as well.  For MTRP PUCCH repetition scheme in Rel-17, due to two beams configured of one PUCCH resource means to towards two TRPs, it is natural to allow one PUCCH resource included in two PUCCH Groups, such that the PUCCH resource can be configured with two beams. For example, PUCCH Group 0 includes {resource 0, 1, 2} and PUCCH Group 1 includes {resource 0, 3, 4}, then PUCCH resource 0 can be configured with two beams which corresponding to PUCCH Group 0 and 1, respectively. |
| LG | This issue will be discussed later after finalizing more urgent issues. |
| MediaTek | OK for further study. |
| Apple | This should be supported. Resource group level beam update in R16 is to fix the overhead issue for resource level beam update in R15 |
| OPPO | Open to discuss it |

### Issue 3: Beam switching gap between PUSCH repetitions for multi-panel UE

**Question 3:** Please indicate your views on discussion to introducing a beam switching gap between PUCCH/PUSCH repetitions (considering both single panel and multi panel assumptions).

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| Company | Comments |
| CATT | According to the discussion in previous meeting, we don’t have consensus on introducing such switching gap. |
| NTT Docomo | Similar view with CATT |
| QC | No need to discuss this. We already concluded this topic, and RAN4 also mentioned that they are no going to provide more inputs. For the case of “unknown beams”, the gap is in the order of hundreds of symbols. We do not think repetition with different beams is even applicable under this assumption. |
| Intel | We are open to discuss PUSCH Type B |
| Ericsson | As we didn’t have consensus for this in past meeting(s), we don’t see the need to discuss this again. |
| ZTE | Similar assessment with companies, this enhancement is unnecessary. |
| LG | In the last meeting we have no consensus to specify symbol gap but it is applied for the same panel assumption, as highlighted by red below.  With reference to the normative work on NR-feMIMO:  Related to the support of switching gap between UL transmissions towards two TRPs in RAN1 specifications, there is no consensus in RAN1 to specify symbol gap(s) for the following cases  • PUSCH Type A  • PUCCH scheme 1  • PUSCH Type B  • PUCCH scheme 3  The above applies for the case included in the LS from RAN4 in R1-2102297.  In case of different panel case, we still need to discuss this issue considering panel activation delay, which is about hundreds of symbols. In order to support back to back PUCCH/PUSCH repetition for different panels without gap symbol, UE should always activates both panels and it leads to more power consumption. Therefore, switching gap is needed. |
| Apple | It is under discussion in 8.1.1 |
| OPPO | No need to discuss |
| Lenovo&MotM | Open to discuss it. |

### Issue 4: Different TA

**Question 4:** Please indicate your views on introducing different UL TA towards different TRPs in m-TRP PUCCH/PUSCH repetition schemes.

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| Company | Comments |
| QC | This was discussed in the past both in this AI and in other Ais. We do not see the need to repeat the discussions. |
| Intel | We have raised this issue since Rel-15 and we are interested in addressing the combined issue of UL and DL with large timing difference, introducing a separate TA would be a piece in this broader scenario but not the only piece, so we don’t support this proposal |
| Ericsson | For Rel-17, we prefer to use the same TA assumption. This could possibly be discussed in a future release. |
| ZTE | Not needed for Rel-17 MTRP PUxCH scheme. |
| LG | In R1-2103511, we provides evaluation results on reception time difference between MTRP when the same UL TA is applied. Our observation is that, for about 20~60% of MTRP UE (depending on various simulation assumption such as SCS, center frequency, etc.), reception time difference is larger than CP even in perfect synchronized network. Furthermore it increases to 60~97% in unsynchronized network with 3 micro second. Given this observation, different UL TA should be supported for MTRP UL performance. |
| MediaTek | Do not see the need to repeat the discussion |
| Apple | Unfortunately this proposal is a bit late, since we failed to reach consensus on gap. Without any gap, it is impossible to apply different TA. |
| OPPO | No need to discuss |
| Lenovo&MotM | No need to discuss it. |

### Issue 5: Power control adjustment states

**Question 5:** Please indicate your views on “twoPUCCH-PC-AdjustmentStates” is separately configured per TRP, and whether RAN1 shall agree/conclude additional clarifications for using the same RRC configuration on “twoPUCCH-PC-AdjustmentStates” for both TRPs.

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| Company | Comments |
| QC | There is only one RRC parameter “twoPUCCH-PC-AdjustmentStates”. It is not clear if clarification is needed. |
| Ericsson | If one ‘twoPUCCH-PC-AdjustmentStates’ parameter is configured for both TRPs, there would be two interpretations:  (1) the parameter is shared across both TRPs, which means there will be two closed loops in total.  (2) the parameter is interpreted as a per TRP parameter, in which case there will be two closed loops per each TRP.  On the other hand, if ‘twoPUCCH-PC-AdjustmentStates’ is configured per TRP (i.e., 2 parameters), then there will be two closed loops per each TRP. So, clarifying this is important as it has implications on the number of closed loops.  Hence, we prefer to clarify this as a conclusion. A similar conclusion may also be needed for PUSCH. |
| QC | @ Ericsson: Our understanding is (1) above. We are ok to have a conclusion if there are different understandings. Other interpretations require spec changes, and hence explicit agreements. |
| MediaTek | Our understanding is the first interpretation, i.e., the parameter is shared across both TRPs, which means there will be two closed loops in total. |
| Apple | We failed to see the necessity |
| OPPO | Share the same view as QC and MediaTek |
| Lenovo&MotM | Same view with QC, no enhancement is needed. |

# Multi-TRP PUSCH transmission

## 3.1 Offline agreements from Phase 0

**Offline agreement 3.7:** Confirm the following,

Working Assumption

For non-codebook based multi-TRP PUSCH, the first SRI field is used to determine the entry of the second SRI field which only contains the SRI(s) combinations corresponding to the indicated rank (number of layers) of the first SRI field. The number of bits, *N2*, for the second SRI field is determined by the maximum number of codepoint(s) per rank among all ranks associated with the first SRI field. For each rank x, the first *Kx* codepoint(s) are mapped to *Kx* SRIs of rank x associated with the first SRS field, the remaining (2N2-*Kx*) codepoint(s) are reserved.



**Offline Agreement 3.11:** For type 2 CG based multi-TRP PUSCH repetition:

* The first (legacy) RRC-configured fields ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’ are associated with the first SRS resource set.
* The second (new) RRC-configured fields ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’ are associated with the second SRS resource set.
* Applying the first, second, or both first and second RRC-configured fields ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’ is determined from the new DCI field (for dynamic switching) of the activating DCI similar to the case of DG-PUSCH.

## 3.2 Feature lead Proposals

### Proposal 3.2: PHR reporting

**Proposal 3.2:** For PHR reporting related to M-TRP PUSCH repetition, option 4 is supported,

* Option 4: Calculate two PHRs, each associated with a first PUSCH occasion to each TRP, and report two PHRs
* FFS1: Required changes to triggering conditions including the required higher layer parameters (e.g.,’phr-PeriodicTimer’, ‘phr-ProhibitTimer’, ‘phr-Tx-PowerFactorChange’ as TRP specific).
* FFS2: Support extensions to both single-cell PHR MAC CE and multi-cell PHR MAC CE
* FFS3: Report P-MPR and MPE per TRP within the same MAC-CE extension.
* FFS4: Send LS to RAN2 as the design details are mainly relevant to RAN2.

Please comment on preferred changes to the proposal. And answer QC, ZTE, FW concerns. If there are no clear support reasoning provided, we can go back to option 1 or 5. I kept most of the comments and removed comments only mentioning ‘support’.

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| Company | Comments |
| QC | Do not support. Option 4 has issues wrt causality of PHR report. In existing spec, PHR-MAC-CE does not include “actual PHR” for future slots. For example, for the case of UL CA, only PUSCHs overlapping in the slot of the PUSCH that carries the MAC-CE are considered.    This is because if PHR for a PUSCH in the future is reported, the scheduling condition for other CCs are not know, and hence, PHR value does not reflect the power allocation on those CCs (which impact the PHR of the target CC).  In addition, Option 4 results in many RAN2 changes including MAC-CE change, triggering condition, introduction of additional timers (if the intention is per-TRP PHR). We do not think there is enough TU in RAN2 for such enhancements.  In our view, Option 1 is the simplest solution, keeps the actual PHR reporting causal (as in current spec), and allows for alternating between the two TRPs for UL CA as well as in the absence of UL CA when dynamic switching of TRP order is allowed.  [Mod] : On the first issue, it is not fully clear why option 4 can not define such a way that it handles the concerns you raised. Also, it does not have to obey always to the current specification and this is a new enhancement. The majority seems to view that per TRP PHR reporting should be supported and build the framework around that. FFS2 appears to be asking the question you raised.  On Ran2 impact, compared to other sub-items, we do not have big changes or work towards RAN2. It should not be a restriction to avoid an enhancement.  Option 1 is not supported by the majority, as you may have seen from contributions. |
| ZTE | Although both option 2 and option 4 can fulfill per TRP PHR reporting, option 2 should be supported with the following analyses.   * For option 2, it can guarantee a great flexibility when considering TRP specific PHR event triggering. Besides, noted that RAN2 time budget is very limited for Rel-17, it can be simple to use one reserved field in Single/Multiple Entry PHR MAC CE to fulfill option 2. * For option 4, it will cause too much spec changes since a new MAC CE design has to be introduced. Besides, it may be mandatory to report two PHR values corresponding to two TRPs every time, no matter whether it is really necessary or not. The signaling overhead will be huge.   In the light of the above elaboration, we think option 2 should be supported to fulfill TRP specific PHR reporting without much specification effort. We suggest to update this proposal as below:  [Draft for offline] Proposal 3.2: For PHR reporting related to M-TRP PUSCH repetition, option 2 is supported,   * Option 2: Calculate two PHRs, each associated with a first PUSCH occasion to each TRP, but report one of them   + FFS: How to select the PHR for reporting. * FFS1: Required changes to triggering conditions including the required higher layer parameters (e.g.,’phr-PeriodicTimer’, ‘phr-ProhibitTimer’, ‘phr-Tx-PowerFactorChange’ as TRP specific). * FFS2: Support extensions to both single-cell PHR MAC CE and multi-cell PHR MAC CE * FFS3: Report P-MPR and MPE per TRP within the same MAC-CE extension. * FFS4: Send LS to RAN2 as the design details are mainly relevant to RAN2.   Mod: Option 4 is supported by a clear majority. Let’s try to discuss FFS points and identify issues/solutions on those. |
| Spreadtrum | Not support the proposal, we share the similar views as ZTE.  For Option4, reporting two PHRs perhaps will introduce new MAC CE, and bring in additional spec work load. It is not preferable, especially considering limited FeMIMO Tus in RAN2. Thus, we prefer option2.  Mod: same comment as ZTE. |
| Futurewei | We suggest to clarify some technical issues first, e.g.:   * Is there any soft combining requirement for the PUSCH repetitions across the TRPs? If yes, then with Option 4, 2 PHR reports have to be sent for all repetitions and this imposes some restriction for RAN2 design. * When sending the first PUSCH, are the PHRs computed based on the first and second (future) PUSCHs? Is the second PHR real (actual) or virtual? * Option 5 and Option 1 are essentially the same. Suggest to clarify.   Mod: Some comments on your questions based on my reading.   * It is not clear why soft combining is related to PHR reporting. Please clarify. * Second PHR can be virtual or actual, according to my reading. But that discussion is indeed needed if we support a report of two values. * They are not the same. Also, it does not matter anymore as companies do not support those. Please check QC contribution as they see it differently. |
| ZTE2 | @FL, given that TDMed repetition scheme is the baseline of Rel-17 MTRP PUSCH, reporting one PHR for one TRP which associated with the first PUSCH occasion is enough and reasonable. Besides, noted that RAN2’s time budgets for Rel-17 is very limited, it is reasonable to adopt a simple approach which minimize spec effort for RAN2, rather than the one which need a new design of MAC CE. Based on the above technical reasons, we believe option 2 should be supported instead of option 4.  Regarding FFS1, it is natural to configure PHR trigger events as TRP specific for more flexibility,which include ‘phr-PeriodicTimer’ for periodically triggering, ‘phr-ProhibitTimer’ for the prohibit timer expires, and ‘phr-Tx-PowerFactorChange’ for change in PL-RS power. How to configure such parameters as TRP specific can be further discussed in RAN1. One straightforward way is to add ‘phr-PeriodicTimer2’, ‘phr-ProhibitTimer2’ and ‘phr-Tx-PowerFactorChange2’ in ‘PHR-Config’. After that, associated each PHR trigger events related parameter set with SRS resource set, respectively.  Regarding FFS2 and FFS3, it can be simple and easy to redesign the current single-cell and multi-cell PHR MAC CE for option 2, which is using one reserved field in the current Single/Multiple Entry PHR MAC CE to indicate the reported PHR towards which TRP. Noted that P-MPR and MPE report per TRP is not required, the redesign of MAC CE for option 2 will not impact the legacy P-MPR and MPE report approach.  Regarding FFS4, it is natural to let RAN2 determine the relevant design for this enhancement. |
| Samsung | Support FL’s proposal. Our first preference is Option 4. Option2 can be also considerable but, for the flexibility Option4 is superior to Option2. For example, gNB can decide whether to support mTRP transmission or sTRP transmission based on the two reported power headrooms of both TRPs. If the remaining power is too small for TRP1 and there is huge remaining power for TRP2, gNB can decide to schedule sTRP PUSCH repetition with TRP2. Two reported power headroom can be helpful to schedule PUSCH transmission or manage transmission power efficiently.  On RAN2’s impact, we have same view with FL. |
| QC2 | We did not see response to our concerns from the supporting companies other than FL’s response. So, I assume companies have noticed the issues raised by us.  @FL: This is a major departure from Rel. 15/16 assumption. With Option 4 (or Option 2), UE’s complexity is increased in a non-trivial way. Basically, this results in a third kind of PHR, which is something between actual and virtual PHR. Then, UE needs to calculate power multiple times: One time for the PHR report for some PUSCH repetition in the future w/o the knowledge of which one of the other CCs have PUSCH, and another time for the actual power calculation for transmission of that repetition. This complexity is not acceptable given that the report PHR is anyway useless most of the time (it does not reflect the actual power).  On the other hand, Option 1 with dynamic switching of TRP order can address the issue, does not increase UE complexity, does not have RAN2 impact, corresponds to the actual power, and does not introduce a third kind of PHR report (semi-actual/semi-virtual PHR). |
| Spreadtrum | Our first preference is Option2. The UE always report the smaller PHR for simplicity. Firstly, it will not introduce much spec efforts. Secondly, reporting one PHR from one TRP is enough. The network can adjust the power based on the smaller PHR for both links, which will not exceed the power headroom of both links.  If majority companies support this proposal, we can accept Option4 for sake of progress. |
| FL Update #2 | **Proposal 3.2:** For PHR reporting related to M-TRP PUSCH repetition, option 4 is supported,   * Option 4: Calculate two PHRs, each associated with a first PUSCH occasion to each TRP, and report two PHRs * FFS1: Required changes to triggering conditions including the required higher layer parameters (e.g.,’phr-PeriodicTimer’, ‘phr-ProhibitTimer’, ‘phr-Tx-PowerFactorChange’ as TRP specific). * FFS2: Support extensions to both single-cell PHR MAC CE and multi-cell PHR MAC CE * FFS3: Report P-MPR and MPE per TRP within the same MAC-CE extension. * FFS4: Send LS to RAN2 as the design details are mainly relevant to RAN2   Concerns: ZTE (prefer Option 2), QC (prefer option 1)  I think there are reasonable comments raised by ZTE and QC. In summary, based on my understanding of the concerns raised, issues are mainly related to the extra work associated with the option 4, deviating from Rel-15/16 framework of PHR reporting, UE complexity, and workload on RAN2. The FFS points are for at least discuss these additional details. My plan is to capture details provided by companies under each FFS and finalize them also if the main bullet is agreeable to all. From FL perspective, as lot of critical details are getting finalized, we do not have to worry much about the workload on this at least in RAN1. Anyways, please provide your justifications so that QC and ZTE can accept the proposal. |
| Futurewei2 | We have similar concerns as expressed by QC2. Would it require the UE to look ahead to a future slot to compute an actual PHR? That is not a small change to existing UE behavior so please clarify. And if PHRs from both TRPs are needed, a dynamic switching of the TRP order can suffice.  @FL: thank you for your replies. For the soft combining question, we thought the PHRs are to be included in the PUSCH repetitions. In previous meetings some companies mentioned that soft combining at the gNB side of the PUSCH repetitions may be desirable. If that’s the case, then the same two PHRs have to be carried in the PUSCH repetitions sent to the two TRPs. Please let us know if we missed anything. |
| NTT Docomo | Regarding QC’s concern that “UE needs to calculate power multiple times” in CA case, in our understanding, the issue UE need to calculate power multiple times also exists in legacy repetition case. So the key issue is whether UE calculate one or two PHR at each time.  And regarding QC’s concern that the PHR does not reflect actual power, in our understanding, even if the PUSCH repetition to the other TRP is in a future slot, the power control parameters are known by UE, so we would like to further understand is the concern that PL or PMPR is not known at the slot of PHR report?  If any misunderstanding, please let us know. |
| QC | @ Docomo: In legacy repetition, there is one set of power control parameters and UE never reports PHR for some PUSCH in the future. Please clarify what you mean by “the issue UE need to calculate power multiple times also exists in legacy repetition case”.  Regarding “even if the PUSCH repetition to the other TRP is in a future slot, the power control parameters are known by UE”, that is not obviously the case. The UE does not know which of the other CC’s have PUSCH. The info that the UE uses for determining actual PHR is specified in 38.213 including the exact timeline conditions:  A UE determines whether a power headroom report for an activated serving cell [11, TS 38.321] is based on an actual transmission or a reference format based on the higher layer signalling of configured grant and periodic/semi-persistent sounding reference signal transmissions and downlink control information the UE received until and including the PDCCH monitoring occasion where the UE detects the first DCI format scheduling an initial transmission of a transport block since a power headroom report was triggered if the power headroom report is reported on a PUSCH triggered by the first DCI format. Otherwise, a UE determines whether a power headroom report is based on an actual transmission or a reference format based on the higher layer signalling of configured grant and periodic/semi-persistent sounding reference signal transmissions and downlink control information the UE received until the first uplink symbol of a configured PUSCH transmission minus *T'proc,2*=*Tproc,2* where *Tproc,2* is determined according to [6, TS 38.214] assuming *d2,1* = 1, *d2,2*=0, and with *µDL* corresponding to the subcarrier spacing of the active downlink BWP of the scheduling cell for a configured grant if the power headroom report is reported on the PUSCH using the configured grant.  This means that the PHR value is likely inaccurate for a PUSCH repetition in the future as UE cannot predict what happens in the future. As a result, all the enhancements and the additional complexity will be not very useful at the end as the reported PHR value does not reflect the actual transmit power. |
| Intel | @QC, our understanding is similar to DOCOMO that UE can calculate ‘virtual’ PHR for the future slot by using current PC setting and some assumption (for e.g. assuming no other uplink transmission). This assumption will also be known to the gNB so receiving the ‘virtual’ PHR is still meaningful to the gNB. |
| Fujitsu | Same view as Intel. |
| QC | @Inte: I do not think intention of the proposal is “virtual PHR”. Otherwise, Option 4 will be even less useful. Virtual PHR is not based on actual scheduling (is not based on the granted PUSCH transmission) and the actual power for the scheduled PUSCH is not reflected in virtual PHR. If virtual PHR for a second beam is to be present, it should be independent of mTRP PUSCH repetition scheduling, e.g., even for a CC not configured with mTRP PUSCH repetition, and configured with DPS (different UL beams / PL-RS configured), a second fixed virtual PHR could be reported. What is the information that gNB obtains from this second “virtual PRH”? It will be pretty much PL value for a fixed beam. For this, we do not need PHR enhancements. We can simply use L1-RSRP, which is even more flexible.  In our understanding, the focus in this proposal is on actual PHR. As we explained before, Option 1 combined with dynamic switching the TRP order, can achieve the goal of per-TRP PHR w/o increasing UE complexity, w/o RAN2 impacts including MAC-CE changes or changing the triggering / timers, and w/o reporting info that may not be very useful in practice. |
| MediaTek | We share the same understanding as NTT Docomo and Intel. @QC, it is unclear to us which parameter(s) about the second beam cannot be known by UE when the timeline is met, either DG or CG, and the actual PHR should be calculated. Can you clarify? |
| Apple | Support the proposal. If QC still has concern, we can try to support option 4 at least for intra-slot repetition. I do not think UE has any problem to predict the power for intra-slot case. |
| OPPO | Support FL proposal. Regarding the multiple calculations for PHR, we share similar view as Docomo / Intel / MediaTeck. |
| Lenovo&MotM | Support. |

### Proposal 3.3: Default PC parameters

**Proposal 3.3:** For single-DCI based M-TRP PUSCH repetition schemes, when one SRS resource per SRS resource set is configured (i.e., when two SRI fields are absent in DCI formats 0\_1 / 0\_2), default P0, alpha, PL-RS, and closed loop index is defined per TRP.

Select one from the following,

* Alt.1
* The first P0/alpha, PL-RS, and closed loop index are determined by *sri-PUSCH-PathlossReferenceRS-Id*, *sri-P0-PUSCH-AlphaSetId*, and *sri-PUSCH-ClosedLoopIndex* mapped to the first *sri-PUSCH-PowerControl* associated with the first SRS resource set.
* The second P0/alpha, PL-RS, and closed loop index are determined by *sri-PUSCH-PathlossReferenceRS-Id*, *sri-P0-PUSCH-AlphaSetId*, and *sri-PUSCH-ClosedLoopIndex* mapped to the first *sri-PUSCH-PowerControl* associated with the second SRS resource set.
* Note: How to design the ignaling link *sri-PUSCH-PowerControl with* two SRS resource sets is up to RAN2.
* Alt.2
* The first set of values {the first value in P0-AlphaSet, the PL-RS corresponded to *PUSCH-PathlossReferenceRS-Id* = 0 and closed-loop index l = 0} can be used for TRP1, and the second set of values {the second value in P0-AlphaSet, the PL-RS corresponded to *PUSCH-PathlossReferenceRS-Id* = 1 and closed-loop index l = 1} can be used for TRP2.
* Alt.3
* If the UE is provided *enablePL-RS-UpdateForPUSCH-SRS*, the first set of values {the first value in *P0-AlphaSet*, the PL-RS corresponding to the first *sri-PUSCH-PowerControl* associated with the first SRS resource set and closed-loop index *l* = 0} is used for TRP1, and the second set of values {the second value in *P0-AlphaSet*, the PL-RS corresponding to the first *sri-PUSCH-PowerControl* associated with the second SRS resource set and closed-loop index *l* = 1} is used for TRP2.
* Otherwise, the first set of values {the first value in *P0-AlphaSet*, the PL-RS with *PUSCH-PathlossReferenceRS-Id=0* and closed-loop index *l* = 0} can be used for TRP1, and the second set of values {the second value in P0-AlphaSet, the PL-RS with *PUSCH-PathlossReferenceRS-Id* = 1 and closed-loop index *l* = 1} can be used for TRP2.

Please provide your concerns (if any). Please check [v062](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/8.1.2.1/Round%200/Draft_FL_Summary_M-TRP_PUCCH_PUSCH_v062_Mod_vivo5.docx) for old discussions (removed to improve the readability of the FL summary).

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| Company | Comments |
| CATT | Either Alt.2 or 3 is supported. |
| NTT Docomo | Support alt.2 or alt.3. |
| QC | Support Alt1. The motivation for Alt2 or Alt3 is not clear. Why would we need different rules when gNB can always configure sri-PUSCH-PowerControl in the case of mTRP PUSCH?  Are we now optimizing RRC overhead? We thought the motivation for the proposal is that mTRP PUSCH should be still possible w/o SRI fields so that when SRS resource set has one SRS resource, we do not need to add DCI overhead just for power control purpose. Alt1 can achieve this, and is the simplest solution.  In addition Alt2 or Alt3 cannot work since closed loop index *l* = 1 may not be even supported by UE. Hence, we think Alt2 or Alt3 should not even be considered. |
| Intel | In principle we are aligned with Alt-1 because switching a UE from sTRP to mTRP mode would anyway involve an RRC reconfiguration so no problem in using sri-PUSCH-PowerControl. for Alt-2, Alt-3 it is unclear why the second set of entries would be suitable as default values for the second TRP (we think the second set of values would be normally configured for another beam from the same TRP) |
| Ericsson | We think it is better to take an agreement on the main bullet for now. We slightly prefer Alt 1, but we can discuss the alternatives in the next meeting. |
| ZTE | After reviewing comments raised by companies so far, we prefer Alt. 3 which is more accurate and reasonable. |
| Fujitsu | Prefer Alt 3. |
| LG | Support alt.2 or alt.3 with the revision for the case UE cannot support closed loop index = 1. If UE cannot support closed loop index = 1, closed loop index = 0 is applied for both TRPs. |
| MediaTek | We prefer Alt. 1. |
| Apple | Support Alt2/Alt3 with modification as follows. Default behavior should not be tied with SRI, otherwise it would create problems for unified TCI state.   * Alt.2 * The first set of values {the first value in P0-AlphaSet, the PL-RS corresponded to *PUSCH-PathlossReferenceRS-Id* = 0 and closed-loop index l = 0} can be used for TRP1, and the second set of values {the second value in P0-AlphaSet, the PL-RS corresponded to *PUSCH-PathlossReferenceRS-Id* = 1 and closed-loop index l = 1 if UE supports 2 closed-loop processes, l=0 otherwise } can be used for TRP2. * Alt.3 * If the UE is provided *enablePL-RS-UpdateForPUSCH-SRS*, the first set of values {the first value in *P0-AlphaSet*, the PL-RS corresponding to the first *sri-PUSCH-PowerControl* associated with the first SRS resource set and closed-loop index *l* = 0} is used for TRP1, and the second set of values {the second value in *P0-AlphaSet*, the PL-RS corresponding to the first *sri-PUSCH-PowerControl* associated with the second SRS resource set and closed-loop index *l* = 1 if UE supports 2 closed-loop processes, l=0 otherwise } is used for TRP2. * Otherwise, the first set of values {the first value in *P0-AlphaSet*, the PL-RS with *PUSCH-PathlossReferenceRS-Id=0* and closed-loop index *l* = 0} can be used for TRP1, and the second set of values {the second value in P0-AlphaSet, the PL-RS with *PUSCH-PathlossReferenceRS-Id* = 1 and closed-loop index *l* = 1 if UE supports 2 closed-loop processes, l=0 otherwise} can be used for TRP2. |
| OPPO | We prefer Alt.1 to get a consistent design |
| Lenovo&MotM | Support Alt 3. And Alt 2 is acceptable. |

### Proposal 3.4: PT-RS DMRS association

**Proposal 3.4:** For single DCI based M-TRP PUSCH Type B repetition, the indication of PTRS-DMRS association for maxRank > 2 is supported by the following option,

* Option 3 (2 bits): 1 bit MSB is used to indicate PTRS-DMRS association for the first TRP, and 1 bit LSB is used to indicate PTRS-DMRS association for the second TRP
  + if *maxNrofPorts* = 1, the 1 bit indicates one of the first two DMRS ports.
  + if *maxNrofPorts* = 2, the 1 bit indicates one of two DMRS ports sharing the same PTRS port.
* Support the proposal: (16) **vivo, CATT, OPPO**, Lenovo, **MediaTek,** **E///**, **LG**, **SS**, **HW, Intel**, **Nokia, NEC, TCL, FW, Fujitsu, Intel**
* Concerns: Apple, QC, Xiaomi, ZTE

Please comment on preferred changes to the proposal.

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| Company | Comments |
| Apple | From performance perspective, we think option 1 is the best. Some more discussion is needed. |
| MediaTek | We can support this proposal. |
| QC | We can support either Option 1 or Option 2, but we do not see Option 3 as a valid / complete solution. Either we support more than 2 layers or not. If we support, the PTRS-DMRS association rule should be also properly designed. |
| Lenovo&MotM | Support. |
| OPPO | Support |
| Samsung | Support FL’s proposal. This method doesn’t increase DCI overhead and it is the unified method for both maxRank ≤2 and maxRank>2. |
| Vivo | Support. |
| ZTE | We have strong concern of this proposal, and RAN1 needs to further assess the rationality of option 3.  For Option 3, it is indeed an incomplete solution which cannot indicate all possible PTRS-DMRS associations. More specifically, when the number of PTRS port is 1, only one of the first two DMRS ports can be selected and associated. Once neither of the first two DMRS ports is the best DMRS port, option 3 will cause performance loss. Likewise, when the number of PTRS port is 2, it means the combination of the two selected and associated DMRS ports is fixed.  For option 1 and option 2, both of them can fully support this enhancement. Differently, option 1 will lead to additional 2 bits DCI overhead, but option 2 will not.  Therefore, we think option 2 should be supported to indicate PTRS-DMRS association when rank > 2, which can guarantee neither DCI overhead increasing nor restrictions of PTRS-DMRS association indication. |
| LG | We don’t agree with the argument that Option 3 is incomplete. It supports PTRS-DMRS association with low resolution by indicating subset of all combination. Even though it cannot indicate best association in some case, as ZTE mentioned, it can still avoid worst association. Also, we don’t see the need of optimizing URLLC PUSCH repetition for rank 3 and 4 since high rank reduces reliability in principle due to inter layer interference and reduced power per layer. |
| NEC | Support the proposal. |
| TCL | We can support this proposal. |
| Xiaomi | We support Option 1, as RAN1 has precluded the limitation of within 2-layer transmission in last meeting, Option 3 should not be considered as a complete solution. It is also not backward compatible for single TRP scenario either. More discussion is needed further on this. |
| Huawei, HiSilicon | We are fine with the proposal. As a compromise, perhaps Option 1 and Option 3 can be configurable. |
| Nokia | We are fine with the proposal if, for maxNrofPorts = 2, Option 3 means the following:   * For each TRP, 1 bit indicates one of two DMRS ports sharing the same PTRS port for two sets of DMRS ports, where each set contains DMRS ports sharing the same PTRS port. The UE then associates the indicated DMRS port in each set to the first and second PTRS ports, respectively.   One alternative for the case maxNrofPorts = 2 is to not support this case, as having two PTRS ports per TRP may not be really justified. |
| Futurewei | Fine with the proposal. |
| Fujitsu | Support FL’s proposal. |
| Ericsson | Support the proposal. We share LG’s view. |
| Intel | Support FL proposal |
| CATT | Support FL’s proposal. |
| FL Update #1 | Majority support the proposal.  Concerns are from Apple, Mtek, QC, Xiaomi.  LG provided some explanations for these companies to rethink and accept the majority view. |
| ZTE2 | With the technical reasons we elaborated before, we do NOT support this proposal so far.  @LG, your comments is a little bit confusing to me. As you said you didn’t agree option 3 is incomplete, then you said option 3 can only indicated subset of all PTRS-DMRS associations, and it can be happened that the best DMRS port will be missed. Based on your above comments, doesn’t it mean that option 3 is an incomplete solution? Regarding rank limitation, hoping you can remember that RAN1 have make a consensus in RAN1 #104-e that maxRank should not be limited in Rel-17 MTRP PUSCH scheme, even we suggested to reach an agreement in #104-e to avoid repeated discussion on this issue but haven’t be adopted. |
| LG | @ZTE, Thanks for the second comment. Maybe we have different understanding of definition of “incomplete” and I think it implies “not working”, but the proposal is working. If you mention it as the proposal cannot cover full combination of PTRS-DMRS association I understand it.  Regarding max rank, as you mention, maxRank is not limited in Rel-17 MTRP PUSCH and that is why we discuss this issue. Rank 3 and 4 can be supported but we don’t see the need of optimizing high rank for URLLC. That is key difference between supporting companies and not supporting companies. |
| Apple | In our understanding, option 3 cannot support full indication. It is hard to say the first and second layer are always the better than the 3rd and 4th layer. Performance wise, this should be the worst compared to option 1 and 2. |
| QC | We can support one of the following, but we cannot support this proposal (option 3), which is the worst option:   * Option 1 * Option 2 * Limit MaxRank to 2   The benefit of Option 1 is simplicity. The benefit of Option 2 is saving DCI overhead. The benefit of limiting maxRank to 2 is that we do not need to discuss this anymore based on some companies input that maxRank>2 is a corner case for mTRP PUSCH.  In option 3, we extend the PTRS-DMRS association to per TRP indication but then we limit it for a given TRP. This does not make sense to us. Then, why not use the same granularity per TRP as in Rel. 15 but apply the same indication to both TRPs (no spec change; just follow Rel. 15)? |
| Xiaomi | Same view as QC, we prefer Option 1. |
| FL Update #2 | **Company views,**   * Support the proposal: (16) **vivo, CATT, OPPO**, Lenovo, **MediaTek,** **E///**, **LG**, **SS**, **HW, Intel**, **Nokia, NEC, TCL, FW, Fujitsu, Intel** * Concerns: Apple, QC, Xiaomi, ZTE   I think the situation is clear, it may not be the best solution for your liking, but something agreeable to majority.  @Apple: For the note, during last meeting, you opposed option 1 (which was FL proposal).  @ZTE: You opposed option 1 so that option 2 can be supported. No one supports Option 2 in this meeting. Let’s not stop the progress.  @QC, Xiaomi: limiting the maxRank = 2 cannot be a better solution that this. Hard to understand that. FL tried option 1 and there were more objections.  @All>> Last meeting these companies objected to option 1, please indicate if they have change of views.  ~~Apple (ok now),~~ LG, SS, ZTE (option 2), Oppo, Intel, TCL |
| QC | @FL: We saw comments from supporting companies that maxRank>2 for mTRP PUSCH repetition Type B is a very corner case. Hence, our earlier comment was that then why are we even discussing this?  Option 3 is not even simple (other than it being incomplete). For *maxNrofPorts* = 2, we do not know if the one bit is used for the first PTRS port or second PTRS port. Describing how this works in the spec requires separate rules for *maxNrofPorts* = 1 and *maxNrofPorts* = 2. |
| Intel | we are open to other ideas but our primary concern is on increasing DCI size. |
| ZTE3 | @FL, please note that I opposed option 3 and option 1 with technical reasons all along. Please find my further comments as below.  First of all, the following motivations should be considered when we determine the solution of indicating PTRS and DMRS association when rank = 3 and 4: (i) all possible PTRS-DMRS associations as Rel-15/16 should be indicated for a complete design; (ii) avoid to cause DCI overhead increasing as much as possible; (iii) minimizing spec change/ impact.  For option 1 v.s. option 2, it can be seen that option 1 requires two additional bits, which will cause DCI overhead further increasing and should be avoided. For option 3 v.s. option 1, it is intuitive that option 3 cannot indicate all PT-RS and DMRS associations for rank = 3 and 4, which is an incomplete solution and doesn’t keep alignment with the cases of rank = 1 or 2.  Based on such above technical analyses, I fail to see the logical to take option 3, which is the worst solution, as way forward. |
| LG | @QC, we would like to respond your question. One bit is used for both first PTRS port and second PTRS port. Specifically, there are up to two DMRS port candidates for PTRS port 0 and another two DMRS port candidates for PTRS port 1, and one bit indicates the first or second candidate for PTRS port 0 and 1 at once. |
| Apple | @FL, to clarify, in last meeting, we supported joint indication with 4-bit indicator compared to separate indication. But the 4-bit joint indication failed to be agreed as an alterantive. Current joint indication option 3 cannot support all the indications. That is why we have concern for current proposal. |

### Proposal 3.5: A-CSI on PUSCH

**Conclusion 3.5.3:** For s-DCI based multi-TRP PUSCH repetition Type A and B, when A-CSI is reported by two PUSCH repetitions, an aperiodic CSI report occupies CPU(s) from the first symbol after the PDCCH triggering the CSI report until the last symbol of the scheduled PUSCH carrying the report ~~(here, the last symbol of the scheduled PUSCH refer to the last symbol of the second PUSCH repetition carrying the report).~~

* No spec impact to clarify this further.

Please provide your concerns (if any). Please check [v062](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/8.1.2.1/Round%200/Draft_FL_Summary_M-TRP_PUCCH_PUSCH_v062_Mod_vivo5.docx) for old discussions (removed to improve the readability of the FL summary).

|  |  |
| --- | --- |
| Company | Comments |
| CATT | Support |
| QC | Ok. In the GTW discussions, Apple mentioned that the text in parenthesis is needed. Then, it would be good if Apple can share their understanding of Rel. 15: Does the CPU occupation end after the first PUSCH repetition or after all PUSCH repetitions in Rel. 15? |
| Ericsson | Ok |
| ZTE | Okay. |
| Fujitsu | Support. |
| MediaTek | OK |
| Apple | We understands QC’s concern that this may be related to the R15 interpretation. We are ok to defer the decision after Rel-15 is clarified. |
| OPPO | OK |

### Proposal 3.6: Dynamic Switching Field

**Proposal 3.6-1:** Confirm the Working Assumption (with supporting two bits for the new field).

* For indicating STRP/MTRP dynamic switching for non-CB/CB based MTRP PUSCH repetition,
  + Introduce a new field in DCI to indicate at least the S-TRP or M-TRP operation.
  + The new field is 2 bits

**Proposal 3.6-2:** For the new field in the DCI for dynamic switching, select Alt.1 or Alt. 2.

**Alt.1**

* Support 2 bits with the following combinations.

|  |  |  |
| --- | --- | --- |
| **Codepoint** | **SRS resource set(s)** | **SRI (for both CB and NCB)/TPMI (CB only) field(s)** |
| 00 | s-TRP mode with 1st SRS resource set (TRP1) | 1st SRI/TPMI field (2nd field is unused) |
| 01 | s-TRP mode with 2nd SRS resource set (TRP2) | 1st SRI/TPMI field (2nd field is unused) |
| 10 | m-TRP mode with (TRP1,TRP2 order)  1st SRI/TPMI field: 1st  SRS resource set  2nd SRI/TPMI field: 2nd SRS resource set | Both 1st and 2nd SRI/TPMI fields |
| 11 | m-TRP mode with (TRP2,TRP1 order)  1st SRI/TPMI field: 2nd SRS resource set  2nd SRI/TPMI field: 1st SRS resource set | Both 1st and 2nd SRI/TPMI fields |

* The SRS resource set with lower ID is the first SRS resource set, and the other SRS resource set is the second SRS resource set.
* The same number of SRS resource shall be configured in the two SRS resource sets.

**Alt.2**

* Support 2 bits with the following combinations.

|  |  |  |
| --- | --- | --- |
| **Codepoint** | **SRS resource set(s)** | **SRI/TPMI (CB only) field(s)** |
| 00 | s-TRP mode with 1st SRS resource set (TRP1) | 1st SRI/TPMI field (2nd field is unused) |
| 01 | s-TRP mode with 2nd SRS resource set (TRP2) | 2nd SRI/ 1st TPMI field (1st SRI and 2nd TPMI fields are unused) |
| 10 | m-TRP mode with (TRP1,TRP2 order)  1st SRI/TPMI field: 1st SRS resource set  2nd SRI/TPMI field: 2nd SRS resource set | Both 1st and 2nd SRI/TPMI fields |
| 11 | m-TRP mode with (TRP2,TRP1 order)  1st SRI/TPMI field: 1st SRS resource set  2nd SRI/TPMI field: 2nd SRS resource set | Both 1st and 2nd SRI/TPMI fields |

|  |  |  |
| --- | --- | --- |
| **Codepoint** | **SRS resource set(s)** | **SRI (NCB only) field(s)** |
| 00 | s-TRP mode with 1st SRS resource set (TRP1) | 1st SRI (2nd field is unused) |
| 01 | s-TRP mode with 2nd SRS resource set (TRP2) | 1st SRI (2nd SRI is unused) |
| 10 | m-TRP mode with (TRP1,TRP2 order)  1st SRI field: 1st SRS resource set  2nd SRI field: 2nd SRS resource set | Both 1st and 2nd SRI fields |
| 11 | m-TRP mode with (TRP2,TRP1 order)  1st SRI field: 1st SRS resource set  2nd SRI field: 2nd SRS resource set | Both 1st and 2nd SRI/TPMI fields |

* The SRS resource set with lower ID is the first SRS resource set, and the other SRS resource set is the second SRS resource set.

Please provide your concerns (if any). Please check [v062](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/8.1.2.1/Round%200/Draft_FL_Summary_M-TRP_PUCCH_PUSCH_v062_Mod_vivo5.docx) for old discussions (removed to improve the readability of the FL summary).

|  |  |
| --- | --- |
| Company | Comments |
| Futurewei2 | Slightly prefer Alt.1. Alt.2 seems a bit more general, but we are not sure why the numbers of SRS resources are different for M-TRP operations. Usually M-TRP is configured when the channels to the TRPs are not very different, so they should be able to support the same number of SRS resources. Anyway we are open for further discussions. |
| Vivo5 | We have concerns on both Alt.1 and Alt.2.  Alt.1 restricts same number of SRS resource configured in the two SRS resource sets, while Alt.2 requires separate interpretation tables for CB and NCB which is not favorable to make the spec complicated.  We still suggest to further study the interpretation table and agree the table in the next meeting. |
| CATT | For Proposal 3.6-1, to save DCI overhead, we still prefer 1-bit new field when the second SRI/TPMI field is present.  For proposal 3.6-2, it is related to proposal 3.6-1. So, it should be discussed after the conclusion on 3.6-1. |
| NTT Docomo | Support proposal 3.6-1  For proposal 3.6-2, our first preference is alt.2 with no restriction on same number of SRS resources. |
| QC | We are fine with both Alts, but prefer Alt1 to make things simple.  Another approach is that for both CB and NCB, SRI and TMPI for first/second TRPs are based on first/second fields irrespective of codepoint. For example, for s-TRP mode with 2nd SRS resource set (TRP2), the number of layers is still determined from the first fields, and the second field is used as in mTRP case (first TMPI/SRI fields are **only** used for # of layers for sTRP). Any issue with this? Then, we do not need to interpret things differently based on the four codepoints. |
| Intel | Support proposal 3.6-1  for 3.6-2, we have a slight preference to alt.2 as SRS resource restriction is unnecessary |
| Ericsson | Support Alt 1. We do not think having different SRS resources in the two SRS resource sets have a good use case. |
| ZTE3 | Regarding proposal 3.6-1, do NOT support the 2-bit new field is always present based on the strong concern of DCI overhead. Note that there are many approaches on saving 2bits of the new field, it worth to cautiously decide whether any approach should be precluded for DCI overhead saving. I hope FL and companies can be ease to the above consideration, and I’m wondering if something like the following proposal might be a middle ground for the sake of progress.  **Roposal 3.6-1:** Confirm the Working Assumption (with supporting two bits for the new field).   * For indicating STRP/MTRP dynamic switching for non-CB/CB based MTRP PUSCH repetition,   + Introduce a new field in DCI to indicate at least the S-TRP or M-TRP operation.   + The new field is 2 bits.   + FFS: whether the new field is present in DCI depends on RRC configuration.   Regarding proposal 3.6-2, the motivation on supporting different number of SRS resource for TRPs is unclear. |
| Fujitsu | Support proposal 3.6-1.  Support Alt-1. Prefer a unified solution for both NCB and CB. |
| LG | Support Alt 1 since use case is not clear for different number of SRS resources per TRP and Alt 1 is unified approach for CB and nonCB. |
| MediaTek | We prefer Alt. 1. |
| Apple | We think it should not be fomulated as for down-selection, but it is about whether the additional restriction on the same number of resources are required for diffferent SRS resource sets. So far we have not seen the necessity, but we are open to FFS. We also failed to see the connection for this restriction and the dynamic switching. |
| NTT Docomo | @Apple: To clarify, the connection for this restriction and two alternatives is that, if two SRS resource sets may have different number of resources, Alt.1 is not beneficial for DCI overhead. Because in Alt.1, each SRI field may correspond to 1st or 2nd SRS resource set in different cases indicated by the dynamic switching field, so the size of 1st and 2nd SRI field is determined assuming maximum number of SRS resources in two SRS resource sets. For example, if 1st SRS resource set has one resource, and 2nd SRS resource set has two resources, with Alt.1, both SRI fields should be 1-bit, while with Alt.2, 1st SRI field is 0-bit, 2nd SRI field is 1-bit. |
| OPPO | Support proposal 3.6-1  For proposal 3.6-2, support Alt1.  For alt 2 in proposal 3.6-2, we do not understand why 2nd SRI/ 1st TPMI field (1st SRI and 2nd TPMI fields are unused) for codepoint 01 in CB based PUSCH. It results in the difference design of CB and NCB based PUSCH which makes spec unreadable.  Secondly, we did not see the need to support different number of SRS resource for TRPs. If different number of SRS resource for TRPs is supported, then different maximum layers can be configured in STRP scenario. For NCB based PUSCH, 1st SRI is always used. For different SRS resource numbers is STRP scenario, the required codepoint of 1st SRI can be different for STRP1, STPR2 and MTRP which complex the design of spec. |
| Lenovo&MotT | Support Alt 1. |

### Proposal 3.9: CG PUSCH – RV mapping

Proposal 3.9: For RV mapping of type 1 or type 2 CG based multi-TRP PUSCH repetition, select one from the following,

* Alt.1: The configured RV sequence (via “*repK-RV*”) is applied separately for PUSCH repetitions corresponding to the first TRP and the second TRP with a an RV offset for the starting RV corresponding to the second TRP (similar to the case of dynamic multi-TRP PUSCH repetition).
* Alt.2: The configured RV sequence (via “*repK-RV*”) is applied separately for PUSCH repetitions corresponding to the first TRP and the second TRP.
* Alt.3: Up to two RV sequences can be configured. If one RV sequence is configured, the same RV sequence is applied separately for PUSCH repetitions corresponding to the first TRP and the second TRP. If two configured RV sequences are configured, RV sequences are applied separately for PUSCH repetitions corresponding to the first TRP and the second TRP.
* FFS1: How the *startingFromRV0* is associated with the initial transmission of a TB corresponding to each TRP.

Alt.1: **Fujitsu, MTek, QC, CATT, MTek, CMCC, LG, NEC, Spreadtrum, Fraunhofer, Nokia, E///, Intel, CATT**

Alt.2: **ZTE, Oppo, Apple, HW,**

Alt.3: **Xiaomi, TCL**

Please provide your concerns (if any). Please check [v062](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/8.1.2.1/Round%200/Draft_FL_Summary_M-TRP_PUCCH_PUSCH_v062_Mod_vivo5.docx) for old discussions (removed to improve the readability of the FL summary).

|  |  |
| --- | --- |
| Company | Comments |
| Futurewei2 | We are trying to fully understand “The configured RV sequence (via “*repK-RV*”) is applied separately …” Is it one (the same) sequence configured for both TRPs or 2 separate sequences? If it’s the same sequence without offset, it means the same RV is transmitted to both TRPs, right? Is there any previous / relevant evaluations? |
| CATT | Support |
| NTT Docomo | Support FL proposal. Support Alt.1. |
| QC | Support Alt1. |
| Ericsson | Alt 1. |
| ZTE | Our preference is Alt. 2. For the sake of progress, we can also live with Alt. 1. |
| Fujitsu | Prefer Alt 1. |
| LG | Support FL proposal. |
| MediaTek | Support Alt. 1. |
| Apple | Support Alt2. We suggest we add another alterantives as follows:  Alt.4: The configured RV sequence (via “*repK-RV*”) is applied across mTRP PUSCH repetitions (No spec change is required) |
| OPPO | We prefer Alt. 2. For the sake of progress, we can also live with Alt. 1 or Alt.4 (proposed by Apple). |

### Proposal 3.10: CG PUSCH – PTRS DMRS association

**Proposed Conclusion 3.10:** For M-TRP PUSCH corresponding to a configured grant Type 1 transmission, the UE may assume the association between UL PT-RS port(s) and DM-RS port(s) defined by value 0 in Table 7.3.1.1.2-25 or value “00” in Table 7.3.1.1.1.2-26 described in Clause 7.3.1 of [5, TS38.212] (similar to s-TRP CG PUSCH operation).

* No spec impact

Concerns: Apple, Xiaomi

Please provide your concerns (if any). Please check [v062](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Inbox/drafts/8.1.2.1/Round%200/Draft_FL_Summary_M-TRP_PUCCH_PUSCH_v062_Mod_vivo5.docx) for old discussions (removed to improve the readability of the FL summary).

|  |  |
| --- | --- |
| Company | Comments |
| CATT | Support |
| NTT Docomo | Support |
| QC | Support. |
| Ericsson | Support |
| ZTE | Support. |
| Fujitsu | Support |
| LG | Support. |
| MediaTek | Support. |
| Apple | Do not support. Port cycling should provide better performance, which does not increase any additional signaling overhead. We suggest we study it with some evaluation. |
| OPPO | Support. |
| Lenovo&Mot | Support |

## 3.3 Additional discussions for Phase 1

### Issue 1: P/SP-CSI on M-TRP PUSCH

**Question 1:** Please indicate your views on supporting enhancements related to P/SP-CSI report on mTRP PUSCH (e.g. the case of collision between PUCCH and PUSCH). If any, indicate the enhancement.

|  |  |
| --- | --- |
| Company | Comments |
| QC | We support the case of SP-CSI on PUSCH, i.e., DCI can activate SP-CSI with 2 PUSCH repetitions and the report is multiplexed on both repetitions.  Note that SP-CSI on PUSCH is quite similar to the case of A-CSI on PUSCH w/o TB in current spec, and the behavior is the same in Rel. 16:  For PUSCH repetition Type B, when a UE receives a DCI that schedules aperiodic CSI report(s) or activates semi-persistent CSI report(s) on PUSCH with no transport block by a '*CSI request'* field on a DCI, the number of nominal repetitions is always assumed to be 1, regardless of the value of *numberOfRepetitions*. When the UE is scheduled to transmit a PUSCH repetition Type B with no transport block and with aperiodic or semi-persistent CSI report(s) by a '*CSI request'* field on a DCI, the first nominal repetition is expected to be the same as the first actual repetition.  Given that we just agreed to the case of A-CSI on PUSCH w/o TB, it makes sense to have similar enhancements also for the case of SP-CSI on PUSCH. |
| Intel | Currently SP-CSI behavior is very similar to A-CSI behavior w/o TB in PUSCH, so it makes sense to also address SP-CSI enhancement in a similar way as A-CSI (repeat towards both TRPs). To be specific, this has nothing to do with PUCCH/PUSCH collision handling. |
| Ericsson | We support the case of SP-CSI on PUSCH. |
| ZTE | Support to further study and discuss until next meeting. |
| LG | Support to further study and discuss until next meeting. |
| MediaTek | We support the case of SP-CSI on PUSCH and we share a similar view as Intel. If the CSI on PUCCH requires high reliability, then it can be transmitted with (M-TRP) PUCCH repetition and the existing R15/R16 PUCCH/PUSCH collision handling can be reused. |
| Apple | Support to reuse A-CSI in mTRP PUSCH for P/SP-CSI in mTRP PUSCH |
| OPPO | Support to further study SP-CSI on PUSCH |

### Issue 1: DMRS sequence initialization

**Question 2:** Please indicate your views on supporting enhancements on per TRP DMRS sequence initialization for both DG-PUSCH and CG-PUSCH

|  |  |
| --- | --- |
| Company | Comments |
| Intel | we support this, note that in FR2 operation, each PUSCH repetition is TDM-ed and is contributing interference to primarily a single target TRP (unlike FR1). In this case TRP specific DMRS sequence allows interference orthogonalization (MU-MIMO) with traffic scheduled in the same cell and interference randomization with traffic scheduled in the neighbor cells |
| Ericsson | We don’t see a strong need to support TRP specific DMRS sequence initialization. How much performance gain do we get by introducing TRP specific DMRS sequence initialization? |
| ZTE | We are supportive to enhance per TRP DMRS sequence initialization.  In Rel-15/16, DMRS initialization ID (which denoted as nSCID) is used to guarantee the resulting DMRS generated from pseudo-random sequence to be orthogonal, which is similar to the virtual cell ID in LTE. If the underlying pseudo-random sequence would differ between different co-scheduled UEs, the resulting DMRSs would not be orthogonal. |
| LG | PUSCH repetition is for increasing reliability and is not typically scheduled with MU-MIMO, targeting eMBB. We don’t see the need of enhancements on per TRP DMRS sequence initialization. |
| MediaTek | Per TRP DMRS sequence initialization may be needed for inter-cell M-TRP, but it can be discussed in AI “8.1.2.2 Enhancements on Multi-TRP inter-cell operation”. We do not see the need for intra-cell M-TRP. |
| Apple | We failed to see the necessity |
| OPPO | More study is needed to justify the benefit |
| Lenovo&MotM | Not needed. |

# Agreements in RAN1 #105-e

**Agreement**

For indicating per-TRP OLPC set in DCI format 0\_1/0\_2, if two SRI fields present in the DCI,

* Use the existing field (1 bit) for OLPC set indication and a second p0-PUSCH-SetList-r16.
  + if value of the field equals to ‘0’, the UE determine value of P0 from*SRI-PUSCH-PowerControl* with a sri-*PUSCH-PowerControlId* value mapped to the SRI field value corresponding to each TRP.
  + if value of the field equals to ‘1’, the UE determine value of P0 from a first value in P0-PUSCH-Set with a p0-PUSCH-SetId value mapped to the SRI field value corresponding to each TRP.

**Agreement**

For s-DCI based multi-TRP PUSCH repetition Type A and B, support ~~multiplexing of~~ transmitting A-CSI on the first PUSCH repetition corresponding to the first beam and the first PUSCH repetition corresponding to the second beam when there is no TB carried in the PUSCH.

* The UE assumes that the number of repetitions ~~where A-CSI is multiplexed with PUSCH~~ is 2 regardless of the indicated number of repetitions.
* The UE is expected to follow the above operation for ~~multiplexing~~ transmitting A-CSI on two PUSCH repetitions only if
  + For PUSCH repetition Type B, the first and second nominal repetitions are expected to be the same as the first and second actual repetitions, respectively (no segmentation).
  + For PUSCH repetition Type A and B, UCIs other than the A-CSI are not multiplexed on any of the two PUSCH repetitions.
* When the UE does not follow the above operation, UE ~~multiplexes~~ transmits A-CSI only on the first PUSCH repetition similar to Rel. 15/16.
* Note: The scheduling offset for the first A-CSI should meet the Z and Z’ requirement

**Agreement**

For s-DCI based multi-TRP PUSCH repetition Type A, the UE is expected to multiplex A-CSI on two PUSCH repetitions only if UCIs other than the A-CSI are not multiplexed on any of the two PUSCH repetitions.

* When the UE does not follow the above operation, UE multiplexes A-CSI only on the first PUSCH repetition similar to Rel. 15/16.

# Reference

|  |  |  |
| --- | --- | --- |
| [R1-2104201](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104201.zip" \t "_parent) | Multi-TRP/panel for non-PDSCH | FUTUREWEI |
| [R1-2104267](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104267.zip) | Enhancements on multi-TRP for reliability and robustness in Rel-17 | Huawei, HiSilicon |
| [R1-2104293](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104293.zip) | Multi-TRP Enhancements for PUCCH and PUSCH | InterDigital, Inc. |
| [R1-2104344](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104344.zip) | Further discussion on Multi-TRP for PUCCH and PUSCH enhancements | vivo |
| [R1-2104405](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104405.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Lenovo, Motorola Mobility |
| [R1-2104412](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104412.zip) | Discussion on enhancements on Multi-TRP for PUCCH and PUSCH | Spreadtrum Communications |
| [R1-2104485](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104485.zip) | Enhancements on PUCCH and PUSCH | CATT |
| [R1-2104586](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104586.zip) | Multi-TRP enhancements for PUCCH and PUSCH | ZTE |
| [R1-2104600](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104600.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | CMCC |
| [R1-2104655](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104655.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Qualcomm Incorporated |
| [R1-2104733](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104733.zip) | Enhancements on Multi-TRP based enhancement for PUCCH and PUSCH | OPPO |
| [R1-2104841](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104841.zip) | Enhancements on Multi-TRP for uplink channels | CAICT |
| [R1-2104889](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104889.zip) | Multi-TRP enhancements for PUCCH and PUSCH | Intel Corporation |
| [R1-2104945](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104945.zip) | Multi-TRP enhancements for PUCCH and PUSCH | Intel Corporation |
| [R1-2104946](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2104946.zip) | Multi-TRP enhancements for PUCCH and PUSCH | Intel Corporation |
| [R1-2105002](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105002.zip) | Multi-TRP enhancements for PUCCH and PUSCH | Intel Corporation |
| [R1-2105003](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105003.zip) | Multi-TRP enhancements for PUCCH and PUSCH | Intel Corporation |
| [R1-2105059](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105059.zip) | Enhancements on Multi-TRP for PDCCH PUCCH and PUSCH | Fujitsu |
| [R1-2105088](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105088.zip) | Views on Rel-17 multi-TRP reliability enhancement | Apple |
| [R1-2105152](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105152.zip) | Considerations on Multi-TRP for PDCCH, PUCCH, PUSCH | Sony |
| [R1-2105247](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105247.zip) | Discussion on multi-TRP for PUCCH and PUSCH | NEC |
| [R1-2105274](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105274.zip) | Enhancements for Multi-TRP URLLC schemes | Nokia, Nokia Shanghai Bell |
| [R1-2105292](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105292.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Samsung |
| [R1-2105350](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105350.zip) | On multi-TRP enhancements for PUSCH | Fraunhofer IIS, Fraunhofer HHI |
| [R1-2105354](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105354.zip) | Enhancements on Multi-TRP for PUCCH and PUSCH | MediaTek Inc. |
| [R1-2105541](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105541.zip) | Enhancements on Multi-TRP for PUSCH and PUCCH | Xiaomi |
| [R1-2105589](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105589.zip) | Enhancements on Multi-TRP for PUCCH and PUSCH | Convida Wireless |
| [R1-2105629](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105629.zip) | Enhancements on Multi-TRP for PUSCH | Sharp |
| [R1-2105684](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105684.zip) | Discussion on MTRP for reliability | NTT DOCOMO, INC. |
| [R1-2105731](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105731.zip) | Discussion on mTRP PUSCH | ASUSTeK |
| [R1-2105780](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105780.zip) | Enhancements on Multi-TRP for PUCCH and PUSCH | LG Electronics |
| [R1-2105808](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105808.zip) | On PUCCH and PUSCH enhancements for multi-TRP | Ericsson |
| [R1-2105817](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105817.zip) | Discussion on enhancements for Multi-TRP for uplink channels | Asia Pacific Telecom, FGI |
| [R1-2105837](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_105-e/Docs/R1-2105837.zip) | Enhancements on Multi-TRP for PUCCH and PUSCH | TCL Communication Ltd. |