3GPP TSG RAN WG1 #106-e R1-210xxxx

e-Meeting, August 16th – 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 document is for the phase 1 discussion of M-TRP PUSCH and PUCCH enhancement for Rel-17. Previous FL summary version can be found in R1-2108298.

R1-2108298 Summary#1 of Multi-TRP for PUCCH and PUSCH Moderator (Nokia)

Latest proposals are in yellow.

FL update is in blue.

#  Multi-TRP PUCCH transmission

The remaining open issues and company views are summarized below. The issues discussed by one or two companies are not listed for now.

## 2.1 Open Proposals

### Issue #2.1: Power control: TPC

**Proposal 2.1:** For per-TRP closed-loop power control,

* When the second TPC field is configured and the indicated PUCCH transmission in DCI formats 1\_1/1\_2 (or PUSCH transmission in DCI formats 0\_1/0\_2) is associated with one “*closedLoopIndex*” value for single TRP transmission, the other TPC field associated with the other “*closedLoopIndex*” value is unused.
	+ Note: Each TPC field is for each closed-loop index value respectively (i.e., 1st /2nd TPC fields correspond to “*closedLoopIndex*” value = 0 and 1, respectively).
* When the indicated PUCCH transmission in DCI format 1\_0 (fallback DCI) is associated with two “*closedLoopIndex*” values for multi-TRP PUCCH transmission schemes, the single TPC field (the existing TPC field) is applied to both closed loop indices for the scheduled PUCCH.

Please comment on preferred changes to the proposal.

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| **Company** | **Comments** |
| **QC** | Support the proposal. For the first bullet: We also do not see the need for optimizations in the case of one closedLoopIndex.For the second bullet: Unlike mTRP PUSCH, mTRP PUCCH only depends on PRI field which exists also in fallback DCI. Hence, the proposal is needed. |
| **LG** | Support the proposal. |
| **Lenovo/MotM** | Support the proposal. |
| **MediaTek** | Support. |
| **Apple** | OK with the proposal. We are also open if the TPC indication is decoupled with the scheduled UL channel, i.e. the first TPC is always for the first CL-PC index and the second TPC is for the second CL-PC index. |
| **Ericsson** | Support FL’s proposal. |
| **NTT Docomo** | Support  |
| **Spreadtrum** | Support FL’s proposal. |
| **NEC** | Support the proposal. |
| **Fujitsu** | Support the proposal. |
| **Samsung** | Support FL’s proposal.  |
| **Vivo** | We think the 1st bullet is not necessary as it is will change UE behavior on PC in our views. The following statement is for PUCCH power control in TS38.213-  is a sum of TPC command values in a set  of TPC command values with cardinality  that the UE receives between  symbols before PUCCH transmission occasion  and  symbols before PUCCH transmission occasion  on active UL BWP  of carrier  of primary cell  for PUCCH power control adjustment state, where  is the smallest integer for which  symbols before PUCCH transmission occasion  is earlier than  symbols before PUCCH transmission occasion If both TPC fields are used, the above spec still works without any change regardless whether both closed loop indices are associated with PUCCH or not, meaning that the accumulated TPC command set for a PUCCH transmission occasion with either closed loop index consists of TPC for the closed loop index received during the TPC accumulated window as shown in the following figure. For the STRP PUCCH with closed loop index *l*=0, TPC accumulated TPC command set consists of TPC 1 and TPC 3 which are received during TPC accumulated window 1, while for the STRP PUCCH with closed loop index *l*=1, TPC accumulated TPC command set consists of TPC 2, TPC 4 and TPC 6 which are received during TPC accumulated window 2.For the second bullet, we are fine. |
| **CMCC** | Support the proposal. |
| **Nokia** | Support the FL’s proposal  |
| **CATT** | Support the proposal. |
| **Huawei, HiSilicon** | Support the proposal. |
| **ZTE** | Support in principle.On the first bullet, note that “Note1” in the previous agreement states that per-TRP closed-loop power control is only applicable when CLIs are not the same for TRPs, but one use case is missing, that is, two beams with two same CLIs for MTRP operation. Besides, regarding the indication of one TPC value by two TRP fields, other solutions may need more discussions and should be listed for further study and down-selection. Hence we suggest to revise this proposal as follows:Proposal 2.1: For per-TRP closed-loop power control, * When the second TPC field is configured and the indicated PUCCH transmission in DCI formats 1\_1/1\_2 (or PUSCH transmission in DCI formats 0\_1/0\_2) is associated with one “*closedLoopIndex*” value for single TRP transmission or with two same “*closedLoopIndex*” values for multi-TRP repetitions,
	+ Alt 1: the second TPC field associated with the other “*closedLoopIndex*” value is unused;
	+ Alt 2: the second TPC field associated with the other “*closedLoopIndex*” value is set as the same value of the first TPC field;
	+ Alt 3: both the first and second TPC fields are jointly indicate the TPC value;
	+ Note: Each TPC field is for each closed-loop index value respectively (i.e., 1st /2nd TPC fields correspond to “*closedLoopIndex*” value = 0 and 1, respectively).
* When the indicated PUCCH transmission in DCI format 1\_0 (fallback DCI) is associated with two “*closedLoopIndex*” values for multi-TRP PUCCH transmission schemes, the single TPC field (the existing TPC field) is applied to both closed loop indices for the scheduled PUCCH.

On the second bullet, we fail to see the motivation to support MTRP PUCCH in fallback DCI. To clear that, one simple way can be that RRC-configured PUCCH resource set for MTRP operation is not available for fallback DCI, which can be up to gNB implementation in reality. |
| **OPPO** | Our first preference is that the 2nd TPC field can be also used, as explained by vivo. Having said that, we can follow majority views for the sake of progress |
| **Fraunhofer IIS/HHI** | Support the proposal |
| **FGI/APT** | We support FL’s proposal. |
| **Xiaomi** | Support the proposal |
| **InterDigital** | Support FL’s proposal.  |
| **Intel** | We are thinking similar operation as explained by Vivo is possible. 2nd bullet is okay. |
| **FL update #1** | **Concerns on the first bullet: vivo, ZTE, Intel****As there is majority support, RAN1 can close this issue by agreeing to the FL proposal.**  |
| **Futurewei** | Support the proposal |
| **Lenovo/MotM** | Support the updated proposal. |
| **TCL** | **Support the proposal** |
| **FL Update #2** | **Proposal 2.1:** For per-TRP closed-loop power control, * When the second TPC field is configured and the indicated PUCCH transmission in DCI formats 1\_1/1\_2 (or PUSCH transmission in DCI formats 0\_1/0\_2) is associated with one “*closedLoopIndex*” value for single TRP transmission, the other TPC field associated with the other “*closedLoopIndex*” value is unused.
	+ Note: Each TPC field is for each closed-loop index value respectively (i.e., 1st /2nd TPC fields correspond to “*closedLoopIndex*” value = 0 and 1, respectively).
* When the indicated PUCCH transmission in DCI format 1\_0 (fallback DCI) is associated with two “*closedLoopIndex*” values for multi-TRP PUCCH transmission schemes, the single TPC field (the existing TPC field) is applied to both closed loop indices for the scheduled PUCCH.

**Concerns on the first bullet: vivo, ZTE, Intel** |
| **Lenovo/MotM** | Support the FL latest proposal. |
| **CATT** | Support the proposal. |
| **Apple** | OK with the latest proposal. If the first bullet if controversial, no further enhancement is also fine, which means each TPC command is for a CL index, regardless of what is scheduled. |
| **ZTE** | We can be fine with this proposal in principle.However, as we mentioned above, one case can be true and is missing in the first bullet, that is two same “*closedLoopIndex*” values for MTRP operation. Besides, it is benefit to fixed the unused TPC field to a default value, e.g. “0”, for further enhance the robustness of DCI decoding. That means once the value of the unused TPC field decoded by UE is not “0”, the decoding error occurs. The following revision is suggested.**Proposal 2.1:** For per-TRP closed-loop power control, * When the second TPC field is configured and the indicated PUCCH transmission in DCI formats 1\_1/1\_2 (or PUSCH transmission in DCI formats 0\_1/0\_2) is associated with one “*closedLoopIndex*” value for single TRP transmission or with two same “closedLoopIndex” values for multi-TRP repetitions, the value of the other TPC field associated with the other “*closedLoopIndex*” value is fixed to “0”.
	+ Note: Each TPC field is for each closed-loop index value respectively (i.e., 1st /2nd TPC fields correspond to “*closedLoopIndex*” value = 0 and 1, respectively).
* When the indicated PUCCH transmission in DCI format 1\_0 (fallback DCI) is associated with two “*closedLoopIndex*” values for multi-TRP PUCCH transmission schemes, the single TPC field (the existing TPC field) is applied to both closed loop indices for the scheduled PUCCH.

@Apple, it is very confusing on your comment “each TPC command is for a CL index, regardless of what is scheduled”. For the case of one CLI with two TPC fields, how does UE understand two TPC command for one CLI? Does it mean TPC value#1 plus TPC value#2, or one of two is ignored? For the case of two same CLIs with two TPC fields, does it mean the two indicated TPC value#1 and TPC value#2 should always be same? We believe this proposal is needed to avoid these ambiguities. |
| **LG** | We are fine with removing first bullet point based on Vivo’s explanation. |
| **MediaTek** | Support the proposal in FL Update #2. We also support ZTE’s revision but with default value “1” which indicates 0 dB for TPC accumulation. |
| **vivo** | If there is no spec change without the FL Update #2 for Proposal 2.1, it would follow our understanding that both TPC fields are used when STRP transmission. In our understanding, there are some cases that the TPC field is still used when no PUSCH is scheduled, such as SPS deactivation, etc. Shall we really add such restriction? |

Issue #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 comment on preferred changes to the proposal.

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| **Company** | **Comments** |
| **QC** | Support. We are also ok with the restriction. Either way, a clear UE behavior or restriction is needed in our view.  |
| **LG** | Do not support. This issue can be addressed by gNB implementation. First of all, gNB can configure up to 128 PUCCH resources. So, gNB can configure one or two spatial relation for the remaining 127 PUCCH resources except for lowest ID PUCCH resource. As a result, there are sufficient scheduling flexibility even if we limit one spatial relation for the lowest ID PUCCH resource. Secondly, gNB anyway needs at least one PUCCH resource with one spatial relation in order to support dynamic switching between MTRP and STRP PUCCH transmission. Therefore, if lowest ID PUCCH resource is limited with one spatial relation, gNB can use it for STRP switching. |
| **Lenovo/MotM** | Support. |
| **MediaTek** | Support. We share the same view as QC. |
| **Apple** | Support. We are also open to define the restriction. |
| **Ericsson** | This issue can be handled via gNB configuring the PUCCH resource with the lowest ID with a single spatial relation info. Having said that, we do not have strong concerns if there is majority support for this proposal.  |
| **NTT Docomo** | Support  |
| **Spreadtrum** | Support. |
| **NEC** | Support the proposal. |
| **Fujitsu** | Share same view as QC. |
| **Samsung** | Support FL’s proposal. Since this issue is already discussed several times, we prefer to make the agreement (or conclusion) for this issue in this meeting. |
| **vivo** | Fine with the proposal. |
| **CMCC** | Support the proposal. |
| **Nokia** | We are fine with the proposal  |
| **CATT** | Support the proposal. |
| **Huawei, HiSilicon** | Don’t support. We would rather prefer to restrict that the PUCCH resource with lowest ID is activated with one spatial relation info. |
| **ZTE** | Support FL’s proposal, which can ensure the flexibility on PUCCH resource configuration especially when considering STRP/MTRP dynamic switching. |
| **OPPO** | Support the proposal |
| **Fraunhofer IIS/HHI** | Support the proposal |
| **FGI/APT** | We support FL’s proposal. Even though this issue can be handled by gNB implementation, we prefer to agree with this proposal for the sake of progress. |
| **Xiaomi** | Support the proposal |
| **InterDigital** | Support FL’s proposal.  |
| **Intel** | Similar view as Ericsson and LG – we think this is low priority optimisation.  |
| **FL update #1** | **Concern**s: LG, HW, Intel. E/// can accept the majority view. Given this was discussed multiple meetings, FL suggest LG , HW, Intel to help the group to close this discussion (regardless the view of small issue). |
| **Futurewei** | Agree with LG and Huawei HiSilicon. |
| **TCL** | **Support the proposal. We share the same view as QC.** |
| **FL update #2** | **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.**Concern**s: **LG, HW, Intel.** |
| **Lenovo/MotM** | **Support FL’s latest proposal.** |
| **CATT** | Support the proposal. |
| **ZTE** | Support. |
| **vivo** | Support |

### Issue #2.3: Scheme 1 – Frequency hopping and beam mapping

**Proposal 2.3:** When inter-slot frequency hopping is configured with Scheme 1, support the following,

* If sequential mapping pattern is configured, frequency hopping is performed on slot level (as in Rel-15).
* If cyclical mapping pattern is configured, frequency hopping is performed among the repetitions with the same beam.

Please comment on preferred changes to the proposal.

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| **Company** | **Comments** |
| **QC** | Support the proposal. As explained before, the benefit in the case of cyclical mapping is opportunistic early termination. We are also ok with gNB to configure whether frequency hopping is at slot level or among the repetitions with the same beam for cyclical mapping. |
| **LG** | Support the proposal. It achieves frequency hopping gain and beam hopping gain simultaneously when cyclical mapping pattern is configured. |
| **Lenovo&MotM** | Support the proposal. It can obtain the frequency diversity gain and spatial diversity gain simultaneously when frequency hopping is performed per beam if cyclical mapping pattern is configured. |
| **MediaTek** | Do not support the proposal. As mentioned by QC, the benefit over sequential mapping with inter-slot FH is merely opportunistic, we fail to identify a systematic gain that worth specifying this feature. |
| **Apple** | Support the proposal. |
| **Ericsson** | For inter-slot multi-TRP PUSCH repetition, we think intra-slot FH can be used for both cyclic mapping and sequential mapping. So we don’t see any need for further enhancements. The proposal in our paper is specific to Scheme 3 and not Scheme 1. |
| **Spreadtrum** | Support the proposal. |
| **NEC** | Fine with the proposal |
| **Fujitsu** | Support the proposal. |
| **Samsung** | Support FL’s proposal. We can obtain the spatial diversity and frequency diversity with frequency hopping among the repetitions with the same beam.  |
| **Vivo** | We do not support. Share similar view as MeidaTek.Firstly, both frequency and beam diversity can still be obtained through the configuration as in the first bullet.Secondly, we are not convinced without any performance gain provided by the proposal. If it is a kind of opportunistic early termination, we can still find the cases that the configuration in first bullet has earlier termination than the second bullet. |
| **CMCC** | Support the proposal as it can achieve beam diversity and frequency diversity gain simultaneously for cyclical mapping pattern. |
| **Nokia** | Do not support. Agree with Mtek.  |
| **CATT** | Support the proposal for NRep >2. Note that when NRep = 2, cyclical mapping is applied regardless of the configuration of beam mapping pattern. A clarification on whether frequency hopping is applied or not for NRep = 2 is needed. When NRep = 2, one of the following candidate solutions can be selected:- Option 1: frequency hopping is performed on slot level.- Option 2: frequency hopping is not applied, all the scheduled frequency resources are used by each repetition.- Option 3: frequency hopping is not applied, half of the scheduled frequency resources are used by each repetition. |
| **Huawei, HiSilicon** | Don’t support the proposal, we have similar view with MTK and Vivo. |
| **ZTE** | We agree with MTK/vivo that the benefit of cyclical mapping is unclear. We prefer FH on slot level for both sequential and cyclical mapping, which is in line with Rel-15 design with no spec impact/change. |
| **OPPO** | Not support and sharing similar view as MTK/vivo |
| **FGI/APT** | We support FL’s proposal. It can ensure that we can obtain spatial diversity and frequency diversity gain no matter cyclical beam mapping pattern or sequential beam mapping pattern is configured. |
| **Xiaomi** | Support the proposal that frequency diversity gain would provide benefits for the cyclic mapping case. |
| **InterDigital** | Don’t support. We share similar view as Ericsson.  |
| **Intel** | similar view as MTK/Ericsson that no specification change is needed |
| **FL Update #1** | **Concerns: MTek, E///, vivo, Nokia, HW, Oppo, ZTE, Intel****Several companies have raised issues. Proponents have explained the use of this multiple times in past few meetings. If group is not converging, we could try GTW discussion (if we get time after some other critical issues).**  |
| **Futurewei** | Agree with MediaTek |
| **TCL** | **Support the proposal as it provides both frequency and beam diversity.** |
| **FL Update #2** | Proposal is copied below (no change). **Proposal 2.3:** When inter-slot frequency hopping is configured with Scheme 1, support the following,   * If sequential mapping pattern is configured, frequency hopping is performed on slot level (as in Rel-15).
* If cyclical mapping pattern is configured, frequency hopping is performed among the repetitions with the same beam.

**Concerns: MTek, E///, vivo, Nokia, HW, Oppo, ZTE, Intel, IDC, FW**A large number of companies believe this proposal is not needed. Proponents may further clarify.  |
| **Lenovo/MotM** | Support the FL’s latest proposal. It can obtain both the frequency diversity gain and spatial diversity gain if frequency hopping can be performed per beam/link when cyclical mapping pattern is configured. |
| **CATT** | Support the proposal for NRep >2. When NRep = 2, whether the frequency hopping scheme follow the configuration of beam mapping pattern or follow the actual beam mapping should be clarified. |
| **Apple** | If this cannot be agreed, we think one way is to use dynamic switching between sequential mapping and cyclic mapping or we can remove cyclic mapping. Otherwise, if this is configured by RRC, most likely cyclic mapping would never be configured. |
| **ZTE** | We still prefer FH always performed on slot level, which can also work and without spec impact/effort. |
| **vivo** | Can the proponents show the performance comparison between the two bullets to see how much benefit of the second bullet can provide? |

### Issue #2.4: Grouping of PUCCH resources

**Proposal 2.4:** For the grouping of PUCCH resources in Rel-17 multi-TRP PUCCH repetition schemes,

* Support MAC-CE activating two spatial relation info’s (for FR2) for a group of PUCCH resources in a CC.
* Support MAC-CE activating two sets of power control parameters (for FR1) for a group of PUCCH resources in a CC.
* When the PUCCH resource is indicated with two spatial relation info’s or two sets of power control parameters, the other PUCCH resources in the group also get updated to have the same two spatial relation info’s or two sets of power control parameters.
* When the PUCCH resource is indicated with one spatial relation info or one set of power control parameters, then the other PUCCH resources in the group also get updated to have the same spatial relation info or the same set of power control parameters.
* The signalling details are up to RAN2 to decide.

Please comment on preferred changes to the proposal.

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| **Company** | **Comments** |
| **QC** | Support the proposal, which is the simplest way to update two beams for a group of PUCCH resources in our view. Up to 4 groups is supported in Rel. 16, which is sufficient in our view. |
| **LG** | It seems better to make high level decision first, i.e., whether MTRP PUCCH and STRP PUCCH can be mixed in the same group, because following issues are different depending on the decision. If they can be mixed in the same group, this proposal means STRP PUCCH resource is updated to MTRP PUCCH resource if MTRP PUCCH resource in the same group is updated by MAC CE, or vice versa, but the benefits and motivation of this is unclear. |
| **Lenovo/MotM** | Do not support the proposal. Reuse the legacy MAC CE of spatial relation information updating for a PUCCH resource group is enough while a PUCCH resource can be included in two different groups which can activate one or two spatial relation information for a PUCCH resource. The specific impact of introducing a new MAC CE is larger than reusing the legacy MAC CE. |
| **MediaTek** | There seems no need to change the number of associated spatial relation info(s) through MAC-CE. Our proposal is not captured in the FL summary and thus copied below:Two PUCCH resource IDs can be configured for a PUCCH resource associated with two spatial relation info’s / power control parameter sets. Each of the two PUCCH resource IDs is associated with a spatial relation info / power control parameter set and a PUCCH resource group.Note that the first PUCCH resource ID can be used for operations not involving PUCCH resource group as in R15. Our scheme has the benefit that the existing MAC-CE can be reused and simultaneously update S-TRP PUCCH and one of the two spatial relation info’s of M-TRP PUCCH. If it is not desirable to have a second ID, we may give it a different name. We provide an example in the following figure: If a MAC-CE indicates ID 0 for updating spatial relation info, then all the spatial relation info’s associated with IDs 0, 2, 4 are updated accordingly. |
| **Apple** | Support the proposal |
| **Ericsson** | Support the proposal |
| **NTT Docomo** | Support  |
| **Spreadtrum** | Similar view as LG. We should first clarify whether allow STRP PUCCH and MTRP PUCCH in same PUCCH group |
| **Fujitsu** | Support the proposal. |
| **Samsung** | Support FL’s proposal. This method to configure two spatial relation info (or two sets of PC parameters) for one PUCCH group seems simpler rather than other methods. We can update two spatial relation infos (or two sets of PC parameters) simultaneously for all PUCCH resources in a group. |
| **vivo** | Support the proposal |
| **CMCC** | Not support the proposal.We have same view as LG. We should discuss the basic framework for grouping of PUCCH resources first. |
| **Nokia** | Support the proposal.  |
| **CATT** | Support the proposal. Whether a PUCCH resource is transmitted in S-TRP manner or M-TRP manner is determined by the number of spatialRelationInfo/power control parameter sets activated by MAC-CE. Therefore all the PUCCH resources in the same group should be activated with the same number of spatialRelationInfo/power control parameter sets. |
| **Huawei, HiSilicon** | We are fine with the proposal. |
| **ZTE** | We have strong concern on this proposal.It should be noted PUCCH Resource Group in Rel-16 corresponds to one spatial relation of one PUCCH resource in FR2. For MTRP PUCCH in Rel-17, different spatial relations of one PUCCH resource means toward different TRPs. To keep alignment with the approach in Rl-16, it should configure two spatial relations of one PUCCH resource in two groups, instead of in one. To achieve the purpose above and minimize spec change for RAN2, one reserved bit (designated as “R”) in the existing “Enhanced PUCCH Spatial Relation Activation/Deactivation MAC CE” [TS 38.321 ] can indicate which one of multiple PUCCH groups containing the spatial relation of PUCCH resource should be updated. For group based update of PC parameters in FR1, same principle should be ensured. We suggest to revise this proposal as follows:Proposal 2.4: For the grouping of PUCCH resources in Rel-17 multi-TRP PUCCH repetition schemes, * Support one PUCCH resource with two spatial relation info’s (for FR2) can be configured in two PUCCH resource groups in a CC, and MAC CE activating all the PUCCH resources within the PUCCH resource group as in Rel-16.
* Support one PUCCH resource with two sets of power control parameters (for FR1) can be configured in two PUCCH resource groups in a CC, and MAC CE activating all the PUCCH resources within the PUCCH resource group as in Rel-16..
* The signalling details are up to RAN2 to decide.
	+ RAN1 identified that one R field in the current “Enhanced PUCCH Spatial Relation Activation/Deactivation MAC CE” can be used for this purpose.
 |
| **OPPO** | Support the proposal |
| **Xiaomi** | Same view as LGE, better to have a common understanding on the basic framework of the grouping |
| **InterDigital** | Support FL’s proposal.  |
| **Intel** | We agree with LGE to agree on the framework first – 1) how many max PUCCH groups 2) whether mTRP and sTRP in same or separate groups 3) is ordering important for the 2 spatial relation info for mTRP PUCCH |
| **FL update #1** | **Concerns:** LG, Lenovo, MTek, Spreadtrum, CMCC, ZTE, Xiaomi, Intel**@LG, Spreadtrum, CMCC, Intel**, **Xiaomi** >> As grouping of PUCCH resources coming from legacy, unless we add extra restriction, it seems that activating one or two spatial relation info for different PUCCH resources within the same PUCCH group can be already supported. Adding more groups, etc are not fully needed unless proponents are aligned on such enhancements. **@MTek** >> Yes, it seems I missed to copy that. But I considered this when comparing different opinions in submitted contributions. The direction of your proposal was not in line with the majority view. **@ZTE** >> Use of reserved entries in MAC-CE is not up to RAN1. To my reading, the direction of the FL proposal is not ruling out your proposal in RAN2 discussions.  |
| **Futurewei** | Fine with the proposal in general, but suggest to discuss based on LG’s comment first. |
| **Lenovo/MotM** | We support ZTE’s proposal where a PUCCH resource can be included in two different PUCCH resources to support MTRP PUCCH transmission. |
| **TCL** | **We share the same view as LGE. We suggest to discuss the basic framework of the grouping first.** |
| **FL update #2** | **Proposal 2.4-1:** For the grouping of PUCCH resources in Rel-17 multi-TRP PUCCH repetition schemes, * Support MAC-CE activating two spatial relation info’s (for FR2) for a group of PUCCH resources in a CC.
* Support MAC-CE activating two sets of power control parameters (for FR1) for a group of PUCCH resources in a CC.
* When the PUCCH resource is indicated with two spatial relation info’s or two sets of power control parameters, the other PUCCH resources in the group also get updated to have the same two spatial relation info’s or two sets of power control parameters.
* When the PUCCH resource is indicated with one spatial relation info or one set of power control parameters, then the other PUCCH resources in the group also get updated to have the same spatial relation info or the same set of power control parameters.
* The signalling details are up to RAN2 to decide.

**Concerns:** **LG, Lenovo, MTek, Spreadtrum, CMCC, ZTE, Xiaomi, Intel, Lenovo****@All>> FL also like to get more inputs for the case which RAN1 fails to agree on the proposal 2.4-1.****Question 2.4-2:** ifthere are no enhancements for grouping of PUCCH resources in Rel-17 multi-TRP PUCCH repetition schemes, what would be your interpretation of the legacy behavior for the UE supporting Rel-17 Multi-TRP PUSCH?* **Alt.1:** Activating one or two spatial relation info for different PUCCH resources within the same PUCCH group is possible.
	+ MAC-CE activating single spatial relation info’s for a group of PUCCH resources is allowed only when all PUCCH resources within the group has one spatial relation info.
* **Alt.2:** Activating one or two spatial relation info for different PUCCH resources within the same PUCCH group is not possible.
	+ MAC-CE activating single spatial relation info’s for a group of PUCCH resources is allowed only when all PUCCH resources within the group has one spatial relation info.
* **Alt.3**: Any other (please indicate)
 |
| Lenovo/MotM | We do not support Proposal 2.4-1. And for Question 2.4-2, we support Alt 1 |
| CATT | Support Proposal 2.4-1. For Question 2.4-2, what does “PUCCH resources has one spatial relation info” mean? SpatialRelationInfo is not configured per PUCCH resource, isn’t it? In our interpretation, whether a PUCCH resource is associated with one or two SpatialRelationInfo should be determined by the MAC-CE that activates SpatialRelationInfo. |
| QC | Support the proposal.We have similar understanding as CATT. Whether one or two beams are activated should depend on MAC-CE (unless if a new RRC parameter is introduced specifically to say 2 beams will be activate at some point in the future, which is a strange design). |
| Apple | Support the proposal.For Question 2.4-2, we think it depends on how RAN2 defines the MAC CE format for 2 spatial relation indication. |
| ZTE | In general, we believe PUCCH group based update is very helpful to save MAC CE overhead and should be supported for Rel-17 MTRP PUCCH.Regrading proposal 2.4-1, there are several issues when activating two spatial relations in one PUCCH group for MTRP PUCCH resource in FR2(same issues in the case of two PC parameter sets in FR1):* Issue#1: If both STRP and MTRP PUCCH resources are mixed in one group, how to update the one spatial relation for STRP PUCCH resource? And which of two spatial relations for MTRP PUCCH resource should be linked to STRP PUCCH resource?
* Issue#2: To address issue#1, one way can be a PUCCH group dedicated to STRP or MTRP PUCCH resources. However, whether the total number of PUCCH groups should be increased for Rel-17? And how many PUCCH groups should be used for STRP/MTRP operation?
* Issue#3: On the third bullet (same issue in forth bullet), group based update for all PUCCH resources with two spatial relations should be fixed, this restriction is unreasonable. Otherwise, which one out of two spatial relations should be updated for all MTRP PUCCH resources in one group?
* Issue#4: A new MAC CE design is required, which leads to more workload for RAN2.

According to the concerns above, we fail to see the logical to adopt the approach as shown in Proposal 2.4-1.By comparison, including two spatial relations of a PUCCH resource in two PUCCH groups respectively should be supported. Based on that, the legacy rules of Rel-16 STRP operation can be ensured, no change on the maximum number of PUCCH groups (up to four RRC-configured PUCCH groups in Rel-16), and reform the existing MAC CE can fulfill this enhancement. Hence we suggest to use the following update proposal:**Proposal 2.4-1:** For the grouping of PUCCH resources in Rel-17 multi-TRP PUCCH repetition schemes, * Support MAC-CE activating the spatial relation info (for FR2) for a group of PUCCH resources in a CC, where the PUCCH resource can be indicated with one or two spatial relation info’s.
* Support MAC-CE activating a set of power control parameters (for FR1) for a group of PUCCH resources in a CC, where the PUCCH resource can be indicated with one or two sets of power control parameters.
* The signalling details are up to RAN2 to decide.
 |
| LG | We need to first discuss whether MTRP PUCCH and STRP PUCCH can be mixed in the same group. The proposal has different meaning depending on the discussion. |
| MediaTek | We can accept that a PUCCH resource group consists of PUCCH resources either all with one spatial relation info or all with two spatial relation info’s. However, it is problematic to update the number of associated spatial relation info’s of PUCCH resources by MAC-CE. The R17 coverage enhancement WI has the following working assumption: • Enhance RRC signaling to allow configuration of PUCCH repetition factor per PUCCH resourceFor a PUCCH resource with one spatial relation info and PUCCH repetition factor 1, if the MAC-CE increases the number of spatial relation info to 2, how about its PUCCH repetition factor?ZTE’s latest proposal is similar to ours, but if it cannot address the issue that a PUCCH resource’s spatial relation info can be updated alone as well. Then, UE does not know which one of the two spatial relation info’s should be updated. ZTE’s latest proposal can be fine if additional restriction is introduced to address the issue. |
| vivo | If Proposal 2.4-1 is not supported, we are also fine with the proposal given by ZTE but with some modifications to make it clear.* **Alt.3**: One PUCCH resource can be configured in two PUCCH resource groups in a CC, and MAC CE activating different spatial relation info for each PUCCH resource group as in Rel-16.
 |

### Issue #2.5: Support Scheme 2

**Proposal 2.5:** Support intra-PUCCH resource beam-hopping (Scheme 2):

* Reuse frequency hopping mechanisms for number of symbols in the first / second beam-hops, and number of DMRS symbols and locations.
* The configured value of *secondHopPRB* can be the same as or different than *startingPRB*.

Please comment on preferred changes to the proposal.

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| **Company** | **Comments** |
| **Lenovo/MotM** | Not support. |
| **QC** | **Support the proposal.****In the previous meeting, some companies asked for evaluation results and comparing Scheme 2 versus Scheme 3. We have provided detailed evaluations illustrating that PUCCH schemes 2 and 3 have the same performance under both cases of with or without blockage for both RM and polar codes. Only when the UCI payload size becomes large (code rate becomes large) with Polar code and with blockage, PUCCH Scheme 3 is slightly better (1dB) than PUCCH Scheme 2. Critical UCIs (HARQ-Ack) do not have very large payload size.****Also, Scheme 2 has multiple important advantages over scheme 3:*** **With PUCCH repetition (Scheme 1 or 3), UCI multiplexing is not possible, which includes the case of multiplexing different UCIs or multiplexing UCI with PUSCH. However, UCI multiplexing rules for Scheme 2 are much more flexible and those restrictive dropping rules are not needed (similar to existing PUCCH frequency hopping).**
* **PUCCH scheme 2 has lower latency as the beam hopping is performed within a given PUCCH resource without the need to conform to sub-slot configurations while in PUCCH scheme 3, different repetitions should be in different sub-slots.**
* **With scheme 2, other PUCCH resources (that do not need mTRP or sub-slot based transmission) can be configured flexibly. With Scheme 3, they have to remain within the sub-slot boundary as in Rel. 16.**
* **The specification impact of Scheme 2 is very small. In our understanding, the proposal above would be enough for the functionality of Scheme 2.**
 |
| **Apple** | **Do not support the proposal. It seems to be redundant since we have agreed intra-slot repetition, and there is not enough time for us to consider a new transmission scheme.** |
| **ZTE** | **Support FL’s proposal.** |
| **LG** | **Support the proposal.** |
| **vivo** | **Support** |

#  Multi-TRP PUSCH transmission

## 3.1 Open Proposals

Issue #3.2: Default PC parameters

**Proposal 3.2:** 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), per TRP default P0, alpha, PL-RS, and closed loop index is defined by,

* 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 signaling link *sri-PUSCH-PowerControl with*two SRS resource sets is up to RAN2.
* 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  *twoPUSCH-PC-AdjustmentStates* is configured, *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  *twoPUSCH-PC-AdjustmentStates* is configured, *l*=0 otherwise } can be used for TRP2.
	+ Note: How to design the signaling link sri-PUSCH-PowerControl with two SRS resource sets is up to RAN2.

Please comment on preferred alternative to down select.

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| **Company** | **Comments** |
| **QC** | Support Alt1. In our understanding, Alt1 is both the simplest and most flexible way (up to gNB how to configure). Alt2/3 force to use two closed loops while the gNB may prefer to not use both closed loops for this purpose (i.e., may want to use the two closed loops for eMBB versus URLLC, or for initial transmission versus retransmission, etc.). In Alt1, this is completely up to the gNB. In addition, Alt1 is a unified way for all ULPC parameters, and we do not think RRC configuration overhead should be concern for mTRP (anyway, RRC configuration is needed for enabling mTRP PUSCH).It would be good to clarify the benefit of Alt3 given that it is both more complicated and less flexible. |
| **LG** | Support Alt 3, which is a straightforward extension of legacy behavior.  |
| **Lenovo&MotM** | Same view with LG, so support Alt 3. |
| **MediaTek** | We support Alt. 1 for its simplicity. |
| **Apple** | Support Alt2. We find there are still a few companies supporting Alt2, we should list Alt2. |
| **Ericsson** | Prefer Alt.1.In Alt.1, the power control parameters associated with each TRP are indicated in the respective SRI to PUSCH power control mapping. This is consistent with the case when SRI field is present in DCI. We don’t understand why it should be conditioned on enablePL-RS-UpdateForPUSCH-SRS as in Alt.3. Also, generally we prefer not to hard code parameters. |
| **NTT Docomo** | Our 1st preference is Alt.2. And second preference can be Alt 3. For alt.1, it does not support the case where SRI-PUSCH-PowerControl is not provided. Because in legacy behavior, default power control parameters are also determined for this case. We would like to understand with alt.1, does it mean we need to further discuss default power control parameters for the case where SRI-PUSCH-PowerControl is not provided, or it means the case where SRI-PUSCH-PowerControl is not provided is not expected for M-TRP PUSCH. |
| **Fujitsu** | Slightly prefer Alt3. |
| **Samsung** | We are fine with Alt 3.  |
| **vivo** | Support Alt 3. Similar view as LG. Alt.1 changes legacy configuration in terms of always configuring sri-PUSCH-PowerControl even when SRI field(s) is absent.@QC: we can’t see the complexity of Alt 3 as it is a straightforward way. As legacy STRP systems don’t support the flexibility to use two closed loops when SRI field is absent, we can’t see any problem to associate each TRP with a dedicate closed loop index in Alt 3. |
| **CMCC** | Support Alt 3.We have the same view with LG and Docomo, Alt 3 is an extension of legacy behavior and Alt 1 doesn’t support the case when the *sri-PUSCH-PowerControl* is not provided. |
| **Nokia** | We are open to further discuss the case where SRI-PUSCH-PowerControl is not provided – raised by DOCOMO. |
| **CATT** | Support Alt 3. Alt 1 is a solution assumes that *sri-PUSCH-ClosedLoopIndex* is always configured for M-TRP scenarios. Whether *sri-PUSCH-ClosedLoopIndex* is configured should be up to gNB’s implementation. |
| **Huawei, HiSilicon** | Prefer Alt 1 for simplicity. |
| **ZTE** | Support Alt. 3.First of all, we think legacy rules on default PC parameters in Rel-15/16 should be taken into account, which are listed below according to the current [TS 38.213]:* Default P0/Alpha

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| If the PUSCH transmission except for the PUSCH retransmission corresponding to a RAR UL grant is scheduled by a DCI format that does not include an SRI field, or if SRI-PUSCH-PowerControl is not provided to the UE, ..., the UE determines  from the value of the first *P0-PUSCH-AlphaSet* in *p0-AlphaSets.**...*If the PUSCH transmission except for the PUSCH retransmission corresponding to a RAR UL grant is scheduled by a DCI format that does not include an SRI field, or if *SRI-PUSCH-PowerControl* is not provided to the UE, , and the UE determines  from the value of the first *P0-PUSCH-AlphaSet* in *p0-AlphaSets.* |

* Default PL-RS Id

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| If - the PUSCH transmission is scheduled by DCI format 0\_0 and the UE is not provided a spatial setting for a PUCCH transmission, or - the PUSCH transmission is scheduled by DCI format 0\_1 or DCI format 0\_2 that does not include an SRI field, or - *SRI-PUSCH-PowerControl* is not provided to the UE, the UE determines a RS resource index $q\_{d}$ with a respective *PUSCH-PathlossReferenceRS-Id* value being equal to zero where the RS resource is either on serving cell$c$ or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*...- If the UE is provided *enablePL-RS-UpdateForPUSCH-SRS*, a mapping between *sri-PUSCH-PowerControlId* and *PUSCH-PathlossReferenceRS-Id* values can be updated by a MAC CE as described in [11, TS38.321]- For a PUSCH transmission scheduled by a DCI format that does not include an SRI field, or for a PUSCH transmission configured by *ConfiguredGrantConfig* and activated, as described in Clause 10.2, by a DCI format that does not include an SRI field, a RS resource index  is determined from the *PUSCH-PathlossReferenceRS-Id* mapped to *sri-PUSCH-PowerControlId* = 0 |

* Default closed loop index

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| - *l* ∈{0, 1}if the UE is configured with *twoPUSCH-PC-AdjustmentStates* and *l* = 0 if the UE is not configured with *twoPUSCH-PC-AdjustmentStates* or if the PUSCH transmission is scheduled by a RAR UL grant as described in Clause 8.3...- If the PUSCH transmission is scheduled by a DCI format that does not include an SRI field, or if an *SRI-PUSCH-PowerControl* is not provided to the UE, *l* = 0. |

Correspondingly, alignment rules for Rel-17 MTRP PUSCH shall be ensured in accordance with the follows:* For default P0/Alpha, it is natural to take the first and second values in P0-AlphaSet for two TRPs, respectively.
* For default PL-RS, when enablePL-RS-UpdateForPUSCH-SRS is configured, PL-RS Ids for two TRPs should be the PUSCH-PathlossReferenceRS-Id value being 0 and 1, respectively. Otherwise, PL-RS Id for two TRPs should be the PUSCH-PathlossReferenceRS-Id mapped with sri-PUSCH-PowerControlId = 0 which associated with the first and second SRS resource set, respectively.
* For default closed loop index, when twoPUSCH-PC-AdjustmentStates is configured, closed loop index equals to 0 and 1 applied for two TRPs, respectively. Otherwise, closed loop index equal to 0 is applied for both TRPs.

Based on the above elaboration, it can be seen that Alt. 3 is most in line with the legacy rules to minimize specification change/effort, but Alt. 1 does deviated from the current design in Rel-15/16, because the RRC-configured mapping between SRI and PUSCH is mandatory, which is inconsistent with the case of default PC parameters in Rel-15/16. Therefore, it makes sense to adopt Alt. 3 as the solution on default PC parameters for Rel-17 MTRP PUSCH repetition. |
| **OPPO** | Support the proposal and prefer Alt.1 for its simplicity |
| **Fraunhofer IIS/HHI** | Support Alt. 3. Agree with ZTE’s views on alignment with legacy behavior. |
| **Xiaomi** | Prefer alt.1 for the simplicity and flexibility |
| **InterDigital** | Prefer Alt. 1, we think it’s more straightforward to use the SRI to PUSCH power control mapping.  |
| **Intel** | Prefer Alt.2. We share the same view as DCM. We need to consider the case where SRI-PUSCH-PowerControl is not provided. |
| **Futurewei** | Alt 1 is a simple and clear solution which works well. |
| **FL update#1** | Added views as below. If companies are ok with Alt.3, I did not list them on other alternatives which do not have good support. **Alt.1 – QC, MTek, E///, HW, OPPO, Xiaomi, FW****Alt. 2 – Apple, Intel****Alt. 3 – LG, Lenovo, DCM, Fujitsu, SS, vivo, CMCC, Nokia, CATT, ZTE, Fraunhofer** The situation is clear on majority support, we need to pick a solution. Let’s go with majority view. **Proposal 3.2:** 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), per TRP default P0, alpha, PL-RS, and closed loop index is defined by, * + 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  *twoPUSCH-PC-AdjustmentStates* is configured, *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  *twoPUSCH-PC-AdjustmentStates* is configured, *l*=0 otherwise } can be used for TRP2.
	+ Note: How to design the signaling link sri-PUSCH-PowerControl with two SRS resource sets is up to RAN2.
 |
| **Lenovo/MotM** | Support FL’s latest proposal. |
| **TCL** | Support Alt1. We think it is simpler in term of spec impact. |
| **CATT** | Support the proposal. |
| **QC** | As commented during GTW, we would like to understand the benefit of Alt3 over Alt1 other than RRC configuration overhead reduction. Do we even need to discuss the case that sri-PUSCH-PowerControl is not configured for mTRP given that various other RRC configurations should be configured to enable mTRP PUSCH anyway? What is the use case? |
| **Apple** | If we want to choose the simplest way, Alt2 should be the best one.  |
| **ZTE** | Support Alt. 3, which is the simplest in fact and most in line with the legacy rules in Rel-15/16 from the perspective of spec change/effort. |
| **LG** | Alt1 needs more complicated UE implementation than Alt3. This is because, if Alt 1 is agreed, not only Alt 1 but also Rel-16 default PC behavior which is the same as Alt 3 except 2nd TRP part should be implemented in Rel-17 UE for the case the UE is serviced in Rel-16 network. |
| **MediaTek** | Support Alt. 1. For signaling design, we think simplicity and flexibility are more important than aligning with the legacy behavior. |
| **vivo** | Support Alt.3.We think the smallest sets of RRC configurations for mTRP PUSCH repetition is two SRS resource sets. Other RRC parameters can follow the legacy configuration, i.e., must be configured or may not configured as Rel-15/16. What we need to do is to specify the behavior when it is not configured by RRC for mTRP cases. That is, now that sri-PUSCH-PowerControl may not be configured for STRP, it may not be configured for mTRP either. |

Issue #3.3: PHR reporting

**Original Proposal 3.3-2:** For option 4, support the following,

* For single cell PHR reporting,
	+ When PHR is triggered for at least one TRP (TRP1 and/or TRP2) and m-TRP PUSCH repetitions scheduled by the DCI are towards TRP1 and TRP2, the reported two PHRs correspond to TRP1 and TRP2 are actual PHRs.
	+ When PHR is triggered for TRP1 and S-TRP PUSCH transmission (or repetitions) scheduled by the DCI is toward TRP1, the reported PHR correspond to TRP1 is an actual PHR and the reported PHR correspond to TRP2 is a virtual PHR.
	+ When PHR is triggered for TRP1 but no PUSCH transmission scheduled by the DCI towards TRP1, PHR is not reported.
* For multi cell PHR reporting,
	+ When the PUSCH carrying PHR in one CC (CC1) overlap with at least one m-TRP PUSCH repetitions of other CC (CC2),
		- If the overlapping is with m-TRP PUSCH repetitions associated with both TRPs, two actual PHRs are calculated for TRP1 and TRP2 based on the first (earliest) repetition corresponding to each TRP in CC2 that overlaps with the first slot in which the PUSCH carrying PHR in CC1.
		- If the overlapping is with m-TRP PUSCH repetitions associated with one TRP (TRP1), the actual PHR is calculated for TRP1 based on the first (earliest) repetition in CC2 that overlaps with the first slot in which the PUSCH carrying PHR in CC1, and virtual PHR is calculated for the other TRP (TRP2).
	+ When the PUSCH carrying PHR in one CC (CC1) does not overlap with at least one M-TRP PUSCH repetitions of other CC (CC2), legacy procedure applied.
* Note: Actual PHR is calculated based on the first PUSCH occasion towards the PUSCH-receiving TRP while virtual PHR is calculated based on a set of default power control parameters defined for the non-receiving TRP.

Please comment on preferred changes to the proposal.

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| **Company** | **Comments** |
| **QC** | Do not support Proposal 3.3-1 in the current form due to the concerns explained in our Tdoc (UE complexity, several ambiguities, and specification impacts). Furthermore, as evident from other Tdocs, different companies have different understandings regarding Option 4, and the complexity/spec impact of different proposals are not the same. Given these concerns, and also the fact that option 4 has majority support, we can accept option 4 if * Option 4 is optional UE capability. A UE should be able to support mTRP PUSCH repetitions w/o having to support Option 4 for PHR
* Option 4 is made simple w/o two actual PHRs unless if both are in the same slot (more explanation regarding this below)

For proposal 3.3-1: Based on the above, we suggest the following to move forwards:**Proposal 3.3-1:** For PHR reporting related to M-TRP PUSCH repetition, support Option 4 as UE optional capability, * Option 4: Calculate two PHRs (at least corresponding to the CC that applies m-TRP PUSCH repetitions), each associated with a first PUSCH occasion to each TRP, and report two PHRs.

If UE does not support Option 4 for PHR, one PHR associated with the first PUSCH occasion (earliest repetition that overlaps with the first slot in which the PUSCH that carries the PHR MAC-CE is transmitted) is reported.For Proposal 3.3.2: Assuming that Option 4 is optional UE capability as suggested above, we are ok with the general direction of this proposal. However, we wanted to mention a few points:* Regarding “PHR is triggered for at least one TRP” or “PHR is triggered for TRP1”, given that PHR configurations are per cell group (common to all CCs), we prefer to not introduce per-TRP PHR triggering. From the MAC layer perspective, existing triggering mechanisms are enough. Otherwise, there will be significant RAN2 impact.
* We prefer to have the same unified design for both non-CA and CA case. Otherwise, we also have to treat two cases for UL-CA differently: Whether mTRP PUSCH carries MAC-CE or another CC carries the MAC-CE
* In the current spec, actual overlap of PUSCH with MAC-CE and other PUSCHs is not important. Instead, whether they are in the same slot or not is important. Same principle should be maintained here for the conditions that the second PHR can be actual.
* PHR reporting for sTRP CCs or sTRP PUSCHs should not be impacted.
* Second PHR value is reported only when the first PHR value is not virtual

Given the above, we suggest to focus on a simple proposal that also reuses Rel. 15/16 mechanisms as much as possible:**Proposal 3.3-2:** For option 4, support the following: When PHR MAC-CE is reported in slot n, for a CC that is configured with mTRP PUSCH repetition, PHR value(s) are determined as* The first PHR value is reported same as Rel. 15/16.
* If the first PHR value is actual PHR (based on Rel. 15/16) corresponding to a repetition among mTRP PUSCH repetitions associated with a given TRP
	+ The second PHR value is actual PHR only when a repetition associated with the other TRP is transmitted in slot n.
	+ Otherwise, the second PHR value is virtual PHR: calculated based on a set of default power control parameters defined for the other TRP (that is not associated with the first PHR)
* If the first PHR value is virtual, a second PHR value is not reported
 |
| **LG** | **Support the proposal 3.3-1. P3.3-2 can be discussed after 3.3-1 is agreed so we prefer to focus on 3.3-1.** |
| **MediaTek** | **Support Proposal 3.3-1 and fine with QC’s revision on Proposal 3.3-1. We also prefer to focus on Proposal 3.3-1 first.** |
| **Apple** | **Support proposal 3.3-1 and 3.3-2 revised by QC.** |
| **Ericsson** | **We support FL’s proposal 3.3-1. Regarding QC’s revision to Proposal 3.3-1, is it QC’s intention to support multiple solutions based on UE capability? In QC’s revision, it seems like if the UE supports the optional capability, then option 4 is supported; if the UE doesn’t support the capability, then Option 1 is supported? It may be better to avoid agreeing to multiple solutions in this way.****We also prefer to focus on Proposal 3.3-1 first, and the next level of details in Proposal 3.3-2 can be discussed once Proposal 3.3-1 is agreed.** |
| **NTT Docomo** | **Support 3.3-1. Also prefer to focus on 3.3-1 first.** **For 3.3-2, we think per TRP PHR triggering needs to be discussed first, otherwise, how to determine PHR is triggered for TRP1 or TRP2 is not clear.** |
| **Samsung** | **Support the proposal 3.3-1. For the proposal 3.3-2, we support the proposal in principle. We also agree to focus on Proposal 3.3-1 first.**  |
| **vivo** | **Support Proposal 3.3-1.****For Proposal 3.3-2, we prefer a unified design with modification below:** **Proposal 3.3-2:** For option 4, support the following, * For single cell PHR reporting,
	+ When PHR is triggered for at least one TRP (TRP1 and/or TRP2) and m-TRP PUSCH repetitions scheduled by the DCI are towards TRP1 and TRP2, the reported two PHRs correspond to TRP1 and TRP2 are actual PHRs.
	+ When PHR is triggered ~~for TRP1 and~~ S-TRP PUSCH transmission (or repetitions) scheduled by the DCI is toward TRP1, the reported PHR correspond to TRP1 is an actual PHR and the reported PHR correspond to TRP2 is a virtual PHR.
	+ When PHR is triggered S-TRP PUSCH transmission (or repetitions) scheduled by the DCI is toward TRP2, the reported PHR correspond to TRP1 is an virtual PHR and the reported PHR correspond to TRP2 is a actual PHR.
	+ ~~When PHR is triggered for TRP1 but no PUSCH transmission scheduled by the DCI towards TRP1, PHR is not reported.~~
* For multi cell PHR reporting,
	+ When the PUSCH carrying PHR in one CC (CC1) overlap with at least one m-TRP PUSCH repetitions of other CC (CC2),
		- If the overlapping is with m-TRP PUSCH repetitions associated with both TRPs, two actual PHRs are calculated for TRP1 and TRP2 based on the first (earliest) repetition corresponding to each TRP in CC2 that overlaps with the first slot in which the PUSCH carrying PHR in CC1.
		- If the overlapping is with m-TRP PUSCH repetitions associated with one TRP (TRP1/TRP2), the actual PHR is calculated for TRP1 based on the first (earliest) repetition in CC2 that overlaps with the first slot in which the PUSCH carrying PHR in CC1, and virtual PHR is calculated for the other TRP (TRP2/TRP1).
	+ When the PUSCH carrying PHR in one CC (CC1) does not overlap with at least one M-TRP PUSCH repetitions of other CC (CC2), legacy procedure applied.
* Note: Actual PHR is calculated based on the first PUSCH occasion towards the PUSCH-receiving TRP while virtual PHR is calculated based on a set of default power control parameters defined for the non-receiving TRP.
 |
| **Nokia** | **We share other companies’ view to first focus on the support of 3.3-1.** **As commented by DOCOMO, we should also clarify the triggering aspect.****In general, we prefer to not have the multi-TRP PHR enhancements as UE capability for similar reasons mentioned by Ericsson.** |
| **CATT** | **Whether per TRP PHR triggering is supported and how to determine which TRP the PHR is triggered for should be clarified first.**  |
| **Huawei, HiSilicon** | **Support both proposals 3.3-1 and 3.3-2.** **For 3.3-2, we can firstly decide whether separate PHR triggering per TRP is needed. For simplicity, it can be supported without signaling impact on RAN2.** |
| **ZTE** | **For proposal 3.3-1, we can be supportive of it. Although our preference is option 2, we can live with option 4 which at least can support per TRP PHR reporting and supported by majority. However, we fail to see the logical to treat option 4 as UE optional capability.****For proposal 3.3-2, we agree with DOCOMO’s assessment.** |
| **OPPO** | We are generally ok with the proposal.For proposal 3.3-2, there 6 cases listed under different conditions such as single cell and multi-cell which complicated the specification. Thus, we are also open to any simple solution to cover all cases. |
| **Convida Wireless** | **Support both proposals 3.3-1 and 3.3-2.** |
| **FGI/APT** | **Support proposal 3.3-1 and we should focus on the proposal 3.3-1 first. For proposal 3.3.2, we share the similar view as DOCOMO.** |
| **Xiaomi** | **We are generally okay with both proposals 3.3-1 and 3.3-2**  |
| **InterDigital** | **Support proposal 3.3-1. We may further discuss 3.3-2 if proposal 3.3-1 is agreed.**  |
| **Intel** | **We have similar view as many companies that we can focus on 3.3-1 first. We prefer the FL version because QC revision creates 2 solutions to address the same problem. Let us try to not create such multiple solutions every time there is a minority opinion.**  |
| **Futurewei** | **We prefer Proposal 3.3-1 suggested by QC.** |
| **FL update #1** | Majority of companies support 3.3-1. On 3.3.-2, it seems companies wish to discuss more prior agreeing to any method. Other than QC, everyone else is ok with the current form of the proposal 3.3-1. **Original Proposal 3.3-1:** For PHR reporting related to M-TRP PUSCH repetition, support Option 4, * Option 4: Calculate two PHRs (at least corresponding to the CC that applies m-TRP PUSCH repetitions), each associated with a first PUSCH occasion to each TRP, and report two PHRs.

Concerns: QCThe update from QC seems applicable to multiple companies, even though few others raise concerns. **Updated Proposal 3.3-1:** For PHR reporting related to M-TRP PUSCH repetition, support Option 4 as UE optional capability, * Option 4: Calculate two PHRs (at least corresponding to the CC that applies m-TRP PUSCH repetitions), each associated with a first PUSCH occasion to each TRP, and report two PHRs.
* If UE does not support Option 4 for PHR, one PHR associated with the first PUSCH occasion (earliest repetition that overlaps with the first slot in which the PUSCH that carries the PHR MAC-CE is transmitted) is reported.

**@All.** Please check whether updated proposal 3.3.-1 is acceptable to you as it allows closing this to progress towards details. I will update the 3.3-2 based on outcome. Also, provide your views on that to further refine earlier version of FL proposal 3.3-2 and QC revision on that.  |
| **FL update #2** | Thanks for accepting proposal 3.3-1. Let’s continue discussion with Proposal 3.3-2. It seems that the updated version on proposal 3.3-2 sent by QC got some support in the phase0 discussions. Also, “*per TRP PHR triggering’* is avoided in that version of the proposal. Also, “*per TRP PHR triggering”* seems to be another controversial aspect when reporting two PHRs. At the end, we shall also look into reasonable scope for RAN2 and not add too much burden on them. Therefore, FL also thinks that suggested version from QC can be considered for further discussion. **Proposal 3.3-2:** For option 4, support the following: When PHR MAC-CE is reported in slot n, for a CC that is configured with mTRP PUSCH repetition, PHR value(s) are determined as, * The first PHR value is reported same as Rel. 15/16.
* If the first PHR value is actual PHR (based on Rel. 15/16) corresponding to a repetition among mTRP PUSCH repetitions associated with a given TRP
	+ The second PHR value is actual PHR only when a repetition associated with the other TRP is transmitted in slot n.
	+ Otherwise, the second PHR value is virtual PHR: calculated based on a set of default power control parameters defined for the other TRP (that is not associated with the first PHR)
* If the first PHR value is virtual, a second PHR value is not reported
 |
| **CATT** | If the first PHR value is actual PHR (based on Rel. 15/16) corresponding to a repetition among mTRP PUSCH repetitions associated with a given TRP, we prefer to calculate actual PHR for the second PHR value if M-TRP PUSCH transmission is scheduled, at least for the case there is a PUSCH repetition for TRP associated to the second PHR in slot n or before slot n. |
| **Apple** | Support the latest proposal 3.3-2 |
| **ZTE** | Generally, we think the aspect of “per TRP PHR reporting” should be supported, because per TRP RRC-configured PC parameters has been agreed. Note that “change in PL-RS received power” is one of PHR triggering events in Rel-15/16, it is unreasonable to preclude such event as TRP specific when per TRP PL-RS can be indicated. Based on the above elaboration, it is very puzzling why only support “per TRP PHR reporting” and “per TRP PC parameters configuration” but without “per TRP PHR reporting” for Rel-17 MTRP PUSCH scheme.Regarding proposal 3.3-2, we share similar view with CATT, which is benefit to scheduling from gNB side due to PC parameters towards two TRPs can be pre-configured for PHR calculation. |
| **LG** | We have similar understanding with CATT. Second PHR can be actual PHR if corresponding PUSCH TO is no later than slot n. Also, on the last bullet, if first PHR is virtual and second virtual PHR can be reported as well. The following is our suggestion.**Proposal 3.3-2:** For option 4, support the following: When PHR MAC-CE is reported in slot n, for a CC that is configured with mTRP PUSCH repetition, PHR value(s) are determined as, * The first PHR value is reported same as Rel. 15/16.
* If the first PHR value is actual PHR (based on Rel. 15/16) corresponding to a repetition among mTRP PUSCH repetitions associated with a given TRP
	+ The second PHR value is actual PHR only when a repetition associated with the other TRP is transmitted ~~in~~no later than slot n.
	+ Otherwise, the second PHR value is virtual PHR: calculated based on a set of default power control parameters defined for the other TRP (that is not associated with the first PHR)
* If the first PHR value is virtual, a second PHR value is virtual and the two PHR are reported ~~not reported~~
 |
| **MediaTek** | We share a similar view as CATT that the second PHR is better to be actual PHR. We think the reference transmission occasion may not be very critical. We propose the following alternative for the first sub-bullet:The second PHR value is actual PHR for a repetition of the same PUSCH associated with the other TRP. The repetition to calculate actual PHR is up to UE implementation.We are fine with LG’s revision on the 3rd bullet but it should be a sub-bullet of the 2nd bullet. |
| **Convida Wireless** | Support the latest proposal 3.3-2. |

Issue #3.4: PT-RS DMRS association

**Proposed conclusion 3.4:** For single DCI based M-TRP PUSCH Type B repetition, the indication of PTRS-DMRS association for maxRank > 2 is based on the legacy framework, i.e., the same PTRS-DMRS association field is applied to both TRPs (to both sets of repetitions).

Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| **QC** | Support the proposal, which is the default assumption in the absence of Options 1-3 (which seemed difficult to converge in the previous meeting) |
| **LG** | **Considering the fact that we agreed to down select one of three options for this issue, we prefer not to revert the agreement. We are open for Option 1 and 3.****Agreement**For single DCI based M-TRP PUSCH Type B repetition, the indication of PTRS-DMRS association for maxRank > 2 is supported, down select one of the following options in RAN1 #105-e meeting, * The support of cyclic mapping can be optional UE feature for the cases when the number of repetitions is larger than 2.
* Option 1 (4 bits): with a second PTRS-DMRS association field (similar to the existing field), and each field separately indicating the association between PTRS port and DMRS port for two TRPs.
* Option 2 (2 bits): using the existing PTRS-DMRS association field in DCI for the first TRP, and using reserved entries/bits in DM-RS port indication field for the second TRP.
* 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.
 |
| **Apple** | For NCB case, we think one way is to use a fixed association as DL, since the precoder is selected by UE and UE can map the best precoder to the lowest port index.For CB case, we think option 1 can provide better performance, if the overhead is really a problem, one possible way is to use PT-RS port cycling. |
| **Ericsson** | Not support the current conclusion. Using the same PTRS-DMRS association to both TRPs is sub-optimal. Plus, the solution in the proposed conclusion is a 4th option that was not part of the previous agreement. We feel it is better to down-select among the 3 options we discussed in the last meeting. Our preference is Option 3. ● 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. |
| **NTT Docomo** | Support  |
| **Spreadtrum** | Support the proposal |
| **Samsung** | For the compromise, we can support Option 3 and Option 1. If RAN1 cannot make convergence, we are open with FL’s proposal.  |
| **Vivo** | We share similar view as LG and we prefer Option 3. |
| **CMCC** | Support the proposal. |
| **Nokia** | Support. Share similar view as QC. |
| **CATT** | Although we prefere option 3. The proposal is acceptable to us. |
| **Huawei, HiSilicon** | We are fine with the proposal. |
| **ZTE** | Do NOT support this proposal.We think the indication of per TRP PTRS-DMRS association should be supported when rank > 2, plus DCI overhead increasing should be avoided as much as possible. For the sake of progress, we can live with option 3 once majority support it, even though our first priority has always been option 2. Hence we suggest to at least list option 3, which supported by many companies, and try to reach a consensus here. |
| **OPPO** | Support the proposal |
| **Xiaomi** | Our preference is option.1, but the FL proposal is acceptable to us for the sake of progress |
| **InterDigital** | Support FL’s proposal.  |
| **Intel** | Agree with E/// and LG that we should start from the agreement in the last meeting. We prefer option-3 |
| **Futurewei** | Support |
| **FL Update #1** | Majority of companies are ok with closing this issue with a conclusion. **@LG, E//, vivo, Intel >>** the proposal is a conclusion that helps formally close this issue. As RAN1 was not able to agree on any alternative listed for last two meetings, but as companies still bring proposals on this with different views (please see the preferences listed even in this round). Therefore, it seems ok to conclude ‘no consensus’. No consensus means legacy behavior applied.**@ZTE>>** it seems option 3 is ok with you. Apple, QC, Xiaomi, ZTE were objecting option 3 in last meeting. We could try Option 3 one more time. **@Apple, E// >>** Yes, performance may not be optimized. Let’s try to see agreeing on option 3, which had least objections last time. **Proposal 3.4:** Select one of the following,**Alt.1:** For single DCI based M-TRP PUSCH Type B repetition, the indication of PTRS-DMRS association for maxRank > 2 is based on the legacy framework, i.e., the same PTRS-DMRS association field is applied to both TRPs (to both sets of repetitions).*Concerns: please indicate change of views (@ZTE, Apple, E///, LG, vivo, Intel).* **Alt.2:** For single DCI based M-TRP PUSCH Type B repetition, the indication of PTRS-DMRS association for maxRank > 2, 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.

*Concerns: please indicate change of views (@Apple, QC, Xiaomi)* |
| **CATT** | Alt 2 is more preferred than Alt 1. Alt 1 is acceptable for the sake of progress.  |
| **QC** | Support Alt1. Both Alt1 and Alt2 are incomplete (either reduced flexibility across TRPs or within a TRP). Then, why should we bother to complicate the spec with Alt2 given that Alt1 is legacy? |
| **Apple** | We do not support either Alt1 or Alt2. We think the previous 4 bits indication is a good apporach. The performance of current Alt1 and Alt2 may be even worset than PT-RS port cycling. Our first preference is a 4-bit indication.If the overhead is a problem, we think we do not need such DCI indication. Then the proposal could be as follows:* For NCB, the PT-RS portis always fixed to be associated with DMRS port with lowst port index among the DMRS ports that share the same PT-RS port
* For CB, the PT-RS portis always fixed to be associated with DMRS port with port index x among the DMRS ports that share the same PT-RS port, where x is the repetition index mod total number of DMRS ports that share the same PT-RS port
 |
| **ZTE** | We prefer Alt.2, which can at least support per TRP PTRS-DMRS association indication and without DCI overhead increasing. |
| **vivo** | Support Alt2. Although it is not perfect, it is better than Alt.1. Alt 2 gives more flexibility for both TRPs to select one better DMRS port. |

Issue #3.5: DCI field on Dynamic Switching

**Question 3.6-2:** On the number of SRS resource configured in the two SRS resource sets, please indicate the preference and the feasibility (with the agreed framework of SRI indication for M-TRP PUSCH repetition) of supporting following alternatives,

* Alt.1: Support the same number of SRS resources for both CB and NCB based m-TRP PUSCH repetition.
* Alt.2: Support different number of SRS resources for both CB and NCB based m-TRP PUSCH repetition. For NCB based PUSCH repetition, first SRS resource set always have the same or larger number of SRS resources than the second SRS resources set.
* Alt.3: Support different number of SRS resources for both CB and NCB based m-TRP PUSCH repetition. For NCB based PUSCH repetition, first SRS resource set always have the smaller, same, or larger number of SRS resources than the second SRS resources set.

Please comment on preferred changes to the proposal.

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| --- | --- |
| **Company** | **Comments** |
| Lenovo/MotM | For question 3.6-2, we support Alt.3. |
| TCL | Support the proposal. For question 3.6-2, we support Alt.1. |
| CATT | Support Alt 2. |
| QC | Slight preference for Alt3, but we can be ok with majority view. |
| NEC | Support Alt 2. |
| Apple | We do not think further discussion is needed |
| ZTE | Support Alt. 1. As we commented before, we fail to see the motivation on configured different number, which is useless and will complicate the specification design for the cases indicated by other codepoints. Once again, it needs to be noted that the following agreement in RAN1 #104-e hints that same SRS resources in two SRS resource sets should be ensured for CB based MTRP PUSCH scheme.

|  |
| --- |
| ***Agreement****For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,* * *Support two SRI fields corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.*
	+ *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: Support dynamic switching the order of two TRPs*
 |

 |
| LG | Support Alt 1. |
| MediaTek | Our first preference is Alt. 2 and the second preference is Alt. 3. |
| vivo | We think for both NCB based and CB based PUSCH repetition, first SRS resource set should have the same or larger number of SRS resources than the second SRS resources set. Different number of UL beams may be applied to the transmission to different TRPs for CB based PUSCH repetition.Then we support Alt 2 with following updates:* Alt.2: Support different number of SRS resources for both CB and NCB based m-TRP PUSCH repetition. The first SRS resource set always have the same or larger number of SRS resources than the second SRS resources set.
 |

Issue #3.7: NCB based PUSCH: number of PT-RS ports

**Proposal 3.7:** For non-codebook based multi-TRP PUSCH repetition, down-selection one of the two alternatives:

* Alt. 1: the actual number of PT-RS ports corresponding to the 1st and 2nd SRS resource sets are the same.
* Alt. 2: the actual number of PT-RS ports corresponding to the 1st SRS resource set can be different from the actual number of PT-RS ports corresponding to the 2nd SRS resource set.

Please comment on preferred changes to the proposal.

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| --- | --- |
| **Company** | **Comments** |
| **QC** | We think following Rel. 15 procedures can result in Alt2 (since PTRS port depends on SRS resources, which are configured separately). We did not see a strong need for the restriction in Alt1. |
| **LG** | Support Alt 1. Use case for Alt 2 is not clear to us.  |
| **Lenovo/MotM** | We prefer to support Alt.2. However, how to determine the TB size should be further clarified if the actual PT-RS ports of different PUSCH repetitions corresponding to different SRS resource sets are be different in Alt. 2.  |
| **Apple** | Support Alt1.  |
| **Ericsson** | Given the number of PUSCH layers are the same for the two TRPs, supporting the same number of PT-RS ports for the two TRPs may be simpler. So, we have a slight preference for Alt. 1. |
| **Spreadtrum** | We prefer Alt.1. |
| **Samsung** | We have the same view as QC. We think alt. 2 is natural way to support NCB mTRP PUSCH. Each SRI can be determined as each SRS resource set and only restriction is the same number of layers. So, the actual number of PTRS ports for each TRP can be different depending on the selected SRI for each TRP. |
| **Vivo** | We share similar views as QC to support Alt.2.Alt.1 is unnecessary. |
| Nokia | We share similar view as Ericsson. |
| **CATT** | Support Alt 2. We share similar views as QC, Samsung and vivo. |
| **ZTE** | We prefer Alt. 2. |
| **OPPO** | Support Alt.1 |
| **Fraunhofer IIS/HHI** | Slightly prefer Alt. 1 as it would be the simpler solution |
| **Xiaomi** | Support alt.2  |
| **InterDigital** | Support FL’s proposal.  |
| **Intel** | Does alt-2 have specification impact ? |
| **Futurewei** | Slightly prefer Alt 1 |
| **FL update #1** | Alt.1 – LG, Apple, E///, Spreadtrum, Nokia, OPPO, Fraunhofer, FWAlt.2 – QC, Lenovo, SS, vivo, CATT, ZTE, Xiaomi@**Lenovo**>> TBS determination does not depend fully on PT-RS REs. The same TB shall be assumed. @**intel** >> No impact based on FL understanding. @**All** >> I hope companies can live with Alt.2. Please indicate if there is any spec impact expected on Alt.2.  |
| **Lenovo/MotM** | We support both Alt 1 and Alt 2. |
| **TCL** | We support Alt. 1. |
| **Fl update #2** | **Proposed conclusion 3.7:** For non-codebook based multi-TRP PUSCH repetition, select Alt.2. * Alt. 2: the actual number of PT-RS ports corresponding to the 1st SRS resource set can be different from the actual number of PT-RS ports corresponding to the 2nd SRS resource set.

**@All** >> Please check the latest update on the proposal (which I changed in to a conclusion) and express any concerns (with details).  |
| Lenovo/MotM | We are fine to FL’s proposed conclusion. |
| CATT | Support. According to current spec, the calculation of TB size for PUSCH is unrelated to the number of PTRS ports. |
| QC | Support. |
| Apple | If we support mixed case, it could be challenging for PT-RS to DMRS port association indication. We also failed to see the use case. In addition, it seems Alt1 is slightly a majority’s view. |
| ZTE | Support FL’s latest proposal. |
| LG | What is the use case of Alt2? In our view, it seems not practical to use 2 panels for PUSCH transmission toward TRP 1 and 1 panel for PUSCH toward TRP 2. If so, why do we need to support Alt2? |
| MediaTek | Fine with FL’s proposed conclusion. |
| vivo | Support. |

Issue #3.8: CG PUSCH: RV mapping

**Proposal 3.8:** For RV mapping of type 1 or type 2 CG based multi-TRP PUSCH repetition, support,

* 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).
* if *startingFromRV0* set to ‘on’, support that the initial transmission can start also from the first transmission occasion and/or any transmission occasions associated with RV=0 for the second TRP, i.e., initial transmission of a transport block may start towards any TRP if the first transmission occasion of the K repetitions is RV = 0 (if configured RV sequence is {0 2 3 1}) or any of the transmission occasions of the K repetitions that are associated with RV = 0 (if the configured RV sequence is {0 3 0 3} or {0,0,0,0}) .
* if *startingFromRV0* set to ‘off’, the initial transmission of a transport block may only start at the first transmission occasion of the K repetitions (same as Rel-15/16).

Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| **QC** | Support the proposal. |
| **LG** | We propose to more relax potential initial transmission TO in case of 0231. Specifically, it is beneficial to make initial transmission possible in the first RV0 transmission occasion of any TRP. For example, if K=8 and RV sequence 00223311 is used for MTRP PUSCH transmission and *startingFromRV0* set to ‘on’, initial transmission can be done in first or second TO, which provides more flexibility. As another example, if RV sequence 03213012 (0231 for TRP1 and 3102 for TRP2) is applied, initial transmission can be done in first or sixth TO, resulting in latency reduction.Our revised proposal is shown below:Proposal 3.8: For RV mapping of type 1 or type 2 CG based multi-TRP PUSCH repetition, support, * 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).
* if *startingFromRV0* set to ‘on’, support that the initial transmission can start also from the first transmission occasion and/or any transmission occasions associated with RV=0 for the second TRP, i.e., ~~initial transmission of a transport block may start towards any TRP if the first transmission occasion of the K repetitions is RV = 0~~ first transmission occasion of any TRP associated with RV = 0 (if configured RV sequence is {0 2 3 1}) or any of the transmission occasions of the K repetitions that are associated with RV = 0 (if the configured RV sequence is {0 3 0 3} or {0,0,0,0}) .
* if *startingFromRV0* set to ‘off’, the initial transmission of a transport block may only start at the first transmission occasion of the K repetitions (same as Rel-15/16).
 |
| **MediaTek** | Support the proposal. |
| **Apple** | We failed to see the necessity for the RV offset. |
| **Ericsson** | Support the proposal. |
| **NTT Docomo** | Support  |
| **NEC** | Support the proposal.In addition, to reduce the latency, it is beneficial to allow UE to start the initial transmission at the first transmission occasions for both first and second TRP, therefore, we suggest the following additional changes in the proposal.* if *startingFromRV0* set to ‘off’, the initial transmission of a transport block may ~~only~~ start at the first transmission occasion of any TRP ~~the K repetitions (same as Rel-15/16)~~.
 |
| **Fujitsu** | Support the proposal. |
| **vivo** | Similar view as Apple.For the second bullet, we do not see the spec impact. |
| **CMCC** | Support the proposal. |
| **Nokia** | Support the proposal in principle, considering the suggested updates below.First, the first part of the second sub-bullet is not fully clear. In addition, the proposal doesn’t seem to cover which PUSCH TOs the UE can use considering the second TRP (assuming a first PUSCH TO with RV0 towards one TRP would be used first). We propose to allow the UE using any PUSCH TO that is associated with the other TRP; otherwise, this will add additional restrictions to which PUSCH TOs can be used as PUSCH transmissions/repetitions, which would at least negatively impact the PUSCH reliability. Hence, we suggest the following updates:Proposal 3.8: For RV mapping of type 1 or type 2 CG based multi-TRP PUSCH repetition, support, * 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).
* if *startingFromRV0* set to 'on', support that ~~the initial transmission can start also from the first transmission occasion and/or any transmission occasions associated with RV=0 for the second TRP, i.e.,~~ initial transmission of a transport block may start towards any TRP if the first transmission occasion of the K repetitions is RV = 0 (if configured RV sequence is {0 2 3 1}) or any of the transmission occasions of the K repetitions that are associated with RV = 0 (if the configured RV sequence is {0 3 0 3} or {0,0,0,0}) . All the later PUSCH transmission occasions towards the other TRP can be used as PUSCH transmissions/repetitions.
* if *startingFromRV0* set to 'off', the initial transmission of a transport block may only start at the first transmission occasion of the K repetitions (same as Rel-15/16). Considering this first transmission occasion is towards one TRP, all the later PUSCH transmission occasions towards the other TRP can be used as PUSCH transmissions/repetitions.
 |
| **CATT** | Support the proposal in principle. In Rel-16, if *startingFromRV0* set to ‘on’, the initial transmission of a transport block may start at any of the transmission occasions of the K repetitions if the configured RV sequence is {0,0,0,0}, except the last transmission occasion when K≥8. Such restriction also can be included in the proposal. |
| **Huawei, HiSilicon** | We are fine with the proposal. |
| **ZTE** | We prefer FL’s proposal. |
| **OPPO** | Support the proposal. The restriction raised by CATT should also be included. |
| **Fraunhofer IIS/HHI** | Support the proposal |
| **FGI/APT** | We support FL’s proposal. |
| **Xiaomi** | We prefer to allow the gNB to configure separate (same or different) RV sequences for the two TRPs instead of using RV\_offset to provide more flexibility for the scheduling, but we can go with the majority view for this. Thus we can support the FL’s proposal. |
| **Futurewei** | Support the proposal |
| **FL update #1** | **@Apple and vivo:** Offset may allow extra level of control on the used RVs. It may be useful to have when the number of repetitions is small.Also, this is in line with the design method we adopted in other discussions.**@LG, Nokia >>** May be wording was not perfect in the earlier proposal, but I think the cases you mentioned in your examples are aligned with the intention. Please see the update.**@NEC >>** *startingFromRV0* set to ‘off’ is only allowing transmission starts with the first transmission occasion. Based on FL understanding, it is good to keep that behavior even for m-TRP as we have the freedom to allowing transmissions in other transmission occasions by setting *startingFromRV0* set to ‘on’. **@CATT, Oppo** >> yes, the restriction as Rel-15 can be mentioned. **@All** >> please see the updated proposal. **Proposal 3.8:** For RV mapping of type 1 or type 2 CG based multi-TRP PUSCH repetition, support, * 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).] % concerns to remove bracket: Apple, vivo
* if *startingFromRV0* set to ‘on’, support that the ~~initial transmission can start also from the first transmission occasion and/or any transmission occasions associated with RV=0 for the second TRP,~~ ~~i.e.,~~ initial transmission of a transport block may start towards any TRP if the first transmission occasion of the K repetitions is RV = 0 (if configured RV sequence is {0 2 3 1}) or any of the transmission occasions of the K repetitions that are associated with RV = 0 (if the configured RV sequence is {0 3 0 3} or {0,0,0,0}. For {0,0,0,0}, ‘any of the transmission’ does not include the last transmission occasion when K≥8).
* if *startingFromRV0* set to ‘off’, the initial transmission of a transport block may only start at the first transmission occasion of the K repetitions (same as Rel-15/16).
* Note: After the initial transmission of a transport block towards one TRP, subsequent PUSCH transmission occasions are also transmitted by following the configured RV sequence for K repetitions.
 |
| **CATT** | **The note is not needed. It seems according to the note, K repetitions are always transmitted. However, whether K repetitions can be transmitted or not depends on the termination conditions specified as in Rel-15.** |
| **QC** | **Ok with the proposal. We are also not sure about the need for the note.** |
| **NEC** | ***startingFromRV0* set to ‘on’**We prefer to use the original wording ‘initial transmission can start also from the first transmission occasion and/or any transmission occasions associated with RV=0 for the second TRP’ for the second bullet of proposal 3.8. Based on our reading, the updated wording for second bullet of FL update #1 ‘initial transmission of a transport block may start towards any TRP if the first transmission occasion of the K repetitions is RV = 0 (if configured RV sequence is {0 2 3 1})’ would restrict the initial transmission towards the second TRP if RV offset configured. See LG’s example, if RV sequence 03213012 (0231 for TRP1 and 3102 for TRP2) is applied, the updated wording would not allow initial transmission in the 6th transmission occasion.***startingFromRV0* set to ‘off’**As to the mechanism when *startingFromRV0* set to ‘off’, we still believe it is beneficial to give the first transmission towards the second TRP the same chance for initial transmission as the first transmission towards the first TRP. New parameter *startingFromSecondTRP* can be introduced for gNB to take control. |
| **Apple** | ***OK with the latest proposal.*** |
| **ZTE** | **We can be fine with this proposal without the note .** |
| **LG** | According to current proposal (specifically, with this wording “if the first transmission occasion of the K repetitions is RV = 0”), initial transmission is possible only in the first transmission occasion in case of RV0231. No matter what RV sequence based on 0231, e.g., RV 00223311 or RV 03213012 for K=8, only first TO has a chance for initial transmission. In order to relax possible TO for initial transmission (for the purpose of reducing latency), as we explained in above phase0 input, we suggest to revise the proposal as shown below. Also, we are fine with NEC’s proposal for the case *startingFromRV0* set to ‘off’ and capture it in the revision.**Proposal 3.8:** For RV mapping of type 1 or type 2 CG based multi-TRP PUSCH repetition, support, * 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).] % concerns to remove bracket: Apple, vivo
* if *startingFromRV0* set to ‘on’, support that the ~~initial transmission can start also from the first transmission occasion and/or any transmission occasions associated with RV=0 for the second TRP,~~ ~~i.e.,~~ initial transmission of a transport block may start in the first RV0 transmission occasion of any TRP ~~towards any TRP if the first transmission occasion of the K repetitions is RV = 0~~ (if configured RV sequence is {0 2 3 1}) or any of the transmission occasions of the K repetitions that are associated with RV = 0 (if the configured RV sequence is {0 3 0 3} or {0,0,0,0}. For {0,0,0,0}, ‘any of the transmission’ does not include the last transmission occasion when K≥8).
* if *startingFromRV0* set to ‘off’, the initial transmission of a transport block can~~may~~ ~~only~~ start at the first transmission occasion for any TRP among~~of~~ the K repetitions ~~(same as Rel-15/16).~~
* Note: After the initial transmission of a transport block towards one TRP, subsequent PUSCH transmission occasions are also transmitted by following the configured RV sequence for K repetitions.
 |
| **MediaTek** | Support the proposal in FL Update #1. |

## 3.2 Additional high priority proposals

If companies wish to bring any additional aspects related to PUSCH during RAN1 #106-e, please comment below.

|  |  |
| --- | --- |
| Company | Comments |
| Lenovo/MotM | Support up to 2 default beams and up to 2 default pathloss reference RSs determination in S-DCI based M-TRP to support M-TRP PUCCH/PUSCH transmission. |
| FL update #1 | **@All** >> Please further indicate if you have similar understanding with Lenovo.  |

# Agreements from Phase 0

**Agreement**

When DCI schedules a retransmission of CG-PUSCH for type 1 CG or type 2 CG (DCI with CRC scrambled with CS-RNTI and NDI=1) while the CG configuration is RRC-configured with two fields of power control parameters, apply the same procedure as DCI activation for CG type 2 agreed before, i.e.,

* 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.

**Agreement**

When fallback DCI (DCI format 0\_0) activates a type 2 CG or schedules a retransmission of a type 1 or type 2 CG, and the CG configuration is RRC-configured with 2 sets of power control parameters (two ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’):

* The UE uses the first set of values for power control (first RRC-configured ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’).

**Agreement**

When a DCI that includes the new 2-bits DCI field for dynamic switching activates a type 2 CG or schedules a retransmission of a type 1 or type 2 CG, and the CG configuration is RRC-configured with only one set of power control parameters (one ‘*p0-PUSCH-Alpha*’ and ‘*powerControlLoopToUse*’):

* The UE expects the new DCI field for dynamic switching is set to “00”, and all PUSCH repetitions are associated with the first SRS resource set.

**Agreement**

For the new field in DCI for dynamic switching,

* For Codepoint “11”, the 1st SRI/TPMI field associate with the 1st SRS resource set while the 2nd SRI/TPMI field associate with the 2nd SRS resource set. i.e.,

|  |  |  |
| --- | --- | --- |
| **Codepoint** | **SRS resource set(s)** | **SRI (for both CB and NCB)/TPMI (CB only) field(s)** |
| 11 | m-TRP mode with (TRP2,TRP1 order)1st SRI/TPMI field: 1st  SRS resource set2nd SRI/TPMI field: 2nd SRS resource set | Both 1st and 2nd SRI/TPMI fields |

* For Codepoint “11”, the first repetition in time is associated with the second SRS resource set, and the remaining repetitions follow the configured mapping pattern (cyclic or sequential).
* For Codepoint “10”, the first repetition in time is associated with the first SRS resource set, and the remaining repetitions follow the configured mapping pattern (cyclic or sequential).

**Agreement**

For PHR reporting related to M-TRP PUSCH repetition, support Option 4 as UE optional capability for a UE that supports mTRP PUSCH,

* Option 4: Calculate two PHRs (at least corresponding to the CC that applies m-TRP PUSCH repetitions), each associated with a first PUSCH occasion to each TRP, and report two PHRs.

**Agreement**

For SP-CSI report on mTRP PUSCH repetition Type A and B activated by a DCI, support the use of a similar mechanism to A-CSI multiplexing on M-TRP PUSCH without a TB, which includes the following,

* When SP-CSI multiplexed on m-TRP PUSCH, SP-CSI multiplexed on the two repetitions associated with the two TRPs, and the number of repetitions is always assumed to be 2, regardless of the value indicated.
* For mTRP PUSCH repetition Type A, or for the first PUSCH after activation for PUSCH repetition Type B**,** reuse similar conditions to support SP-CSI multiplexing on m-TRP PUSCH as defined in A-CSI multiplexing on M-TRP PUSCH, i.e.,
	+ The UE is expected to follow the above operation for transmitting SP-CSI on two PUSCH repetitions only if
		- For the first PUSCH after activation 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 SP-CSI are not multiplexed on any of the two PUSCH repetitions.
	+ When the UE does not follow the above operation, UE transmits SP-CSI only on the first PUSCH repetition similar to Rel. 15/16.
* For subsequent PUSCHs after activation (without corresponding PDCCH) for PUSCH repetition Type B, use the following criteria,
	+ If the first / second nominal repetition is not the same as the first / second actual repetition, the first / second nominal repetition is dropped
		- If one of the first or second nominal repetitions is not dropped, SP-CSI is multiplexed on that repetition
	+ Else (the first and second nominal repetitions are the same as the first and second actual repetitions)
		- If UCIs other than the SP-CSI are not multiplexed on any of the two PUSCH repetitions, SP-CSI is multiplexed on both repetitions.
		- Otherwise, UE transmits SP-CSI only on the first PUSCH repetition similar to Rel. 15/16 (and the second repetition is dropped)

**Agreement**

For indicating per-TRP OLPC set in DCI format 0\_1/0\_2, if no SRI field presents in the DCI,

* Use the existing field (1 or 2 bits) for OLPC set indication and the second p0-PUSCH-SetList-r16.
	+ if value of the field equals to ‘0’ or ‘00’, the UE determine two values of P0 for two TRPs (one P0 value for each TRP) from the first and the second default P0 values.
		- Note: per TRP default P0 values to be decided in separate discussion (alt.1, alt.2, alt.3 in default power control parameter sets).
	+ if value of the field equals to ‘1’ or ‘01’, the UE determine two values of P0 for two TRPs (one P0 value for each TRP) from the **first value** in the first *P0-PUSCH-Set-r16\_list* and the **first value** in the **second** *P0-PUSCH-Set-r16\_list*.
	+ if value of the field equals to ‘10’ or ‘11’, the UE determine two values of P0 for two TRPs (one P0 value for each TRP) from the **second value** in the first *P0-PUSCH-Set-r16\_list* and the **second value** in the **second** *P0-PUSCH-Set-r16\_list.*

# Reference

|  |  |  |
| --- | --- | --- |
| [R1-2106464](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106464.zip) | Enhancements on multi-TRP for reliability and robustness in Rel-17 | Huawei, HiSilicon |
| [R1-2106542](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106542.zip) | Multi-TRP enhancements for PDCCH, PUCCH and PUSCH | ZTE |
| [R1-2106572](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106572.zip) | Further discussion on Multi-TRP for PDCCH, PUCCH and PUSCH enhancements | vivo |
| [R1-2106641](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106641.zip) | Discussion on Enhancements for PDCCH, PUCCH, and PUSCH | InterDigital, Inc. |
| [R1-2106667](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106667.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Lenovo, Motorola Mobility |
| [R1-2106686](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106686.zip) | Discussion on enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Spreadtrum Communications |
| [R1-2106790](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106790.zip) | Considerations on Multi-TRP for PDCCH, PUCCH, PUSCH | Sony |
| [R1-2106866](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106866.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Samsung |
| [R1-2106936](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106936.zip) | Enhancements on multi-TRP/panel transmission for PDCCH, PUCCH and PUSCH | CATT |
| [R1-2107030](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107030.zip) | Enhancements on Multi-TRP for PDCCH PUCCH and PUSCH | Fujitsu |
| [R1-2107079](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107079.zip) | Multi-TRP/panel for non-PDSCH | FUTUREWEI |
| [R1-2107144](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107144.zip) | Discussion on multi-TRP for PDCCH, PUCCH and PUSCH | NEC |
| [R1-2107204](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107204.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | OPPO |
| [R1-2107293](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107293.zip) | Discussion on enhancements on multi-TRP for uplink channels | FGI, Asia Pacific Telecom |
| [R1-2107324](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107324.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Qualcomm Incorporated |
| [R1-2107391](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107391.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | CMCC |
| [R1-2107465](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107465.zip) | On multi-TRP enhancements for PDCCH and PUSCH | Fraunhofer IIS, Fraunhofer HHI |
| [R1-2107486](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107486.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | MediaTek Inc. |
| [R1-2107571](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107571.zip) | Multi-TRP enhancements for PDCCH, PUCCH and PUSCH | Intel Corporation |
| [R1-2107719](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107719.zip) | Views on Rel-17 multi-TRP reliability enhancement | Apple |
| [R1-2107815](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107815.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | LG Electronics |
| [R1-2107839](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107839.zip) | Discussion on MTRP for reliability | NTT DOCOMO, INC. |
| [R1-2107894](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107894.zip) | Enhancements on Multi-TRP for PDCCH, PUSCH and PUCCH | Xiaomi |
| [R1-2108020](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108020.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | Convida Wireless |
| [R1-2108053](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108053.zip) | Enhancements for Multi-TRP URLLC schemes | Nokia, Nokia Shanghai Bell |
| [R1-2108072](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108072.zip) | Enhancements on Multi-TRP for PDCCH, PUCCH and PUSCH | TCL Communication Ltd. |
| [R1-2108074](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108074.zip) | On PDCCH, PUCCH and PUSCH enhancements for multi-TRP | Ericsson |
| [R1-2108106](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108106.zip) | Discussion on mTRP PXXCH | ASUSTeK |

# Previous Agreements

## 5.1 PUCCH

### 102-e (August 2020)

**Agreement**

* Detailed assumptions for PUCCH evaluation:

|  |  |
| --- | --- |
| Parameters | Potential values |
| Baseline scheme | Rel-15 PUCCH repetition |
| PUCCH format | Format 1 and 3. Other PUCCH Formats can be optionally considered.  |
| # of RBs/symbols | PUCCH Format 1: 4 symbols, 1 RBPUCCH Format 3: 4 and 8 symbols, 1 RBOther combinations are not precluded.  |
| UCI payload  | 2 bits for PUCCH Format 1 (and Format 0, if considered). Companies to report assumptions on other PUCCH Formats  |
| Frequency hopping | Reported by companies |
| Number of repetitions (when applicable) | 2, 4, 8 |
| Schemes | TDMDetails to be reported by companies |
| Receiver assumption | Reported by companies |

* Detailed assumptions for PUSCH evaluation:

|  |  |
| --- | --- |
| Parameters | Potential values |
| Baseline scheme | Rel-15/-16 PUSCH repetition |
| # of RBs/symbols | Companies to Report.  |
| DMRS pattern | DM-RS configuration type 1DM-RS Configuration type 2 (optional) |
| # of layers | 1, 2 (optional)  |
| Code rates | Low (<0.2) and moderate (<0.4) |
| Frequency hopping | Reported by companies |
| UL transmission scheme | Codebook based UL transmission is baseline. Non-codebook based can be optional. |
| Redundancy Version | Reported by companies |
| Number of repetitions (when applicable) | 2, 4, 8 Other numbers are not precluded |
| Schemes | TDMDetails to be reported by companies |
| Receiver assumption | Reported by companies |

**Agreement**

To improve reliability and robustness for PUCCH using multi-TRP and/or multi-panel, consider all PUCCH formats.

**Agreement**

To enable TDMed PUCCH transmission with different beams, support configuring/activating of multiple PUCCH Spatial Relation Info. RAN1 shall further study the exact schemes considering the following aspects,

* Method of configuration/activation of multiple spatial relation info
* Use of the same PUCCH resource or different PUCCH resource for PUCCH transmission
* Mapping between PUCCH repetition/symbol and spatial relation info among multiple PUCCH repetitions / multiple PUCCH symbols.

**Agreement**

For configuration/indication of the number of PUCCH repetitions, RAN1 shall further study the following,

* Alt.1: Use Rel-15 like framework
* Alt.2: Dynamic indication of the number of PUCCH repetitions

**Agreement**

For multi-TRP PUCCH transmission, further investigate required power control enhancement.

**Agreement**

Support TDMed PUCCH scheme(s) to improve reliability and robustness for PUCCH using multi-TRP and/or multi-panel. Study the following alternatives,

* Alt.1: supporting both inter-slot repetition and intra-slot repetition / intra-slot beam hopping.
* Alt.2: supporting only inter-slot repetition
* Note1: It is not precluded to study the use of multiple PUCCH resources to repeat the same UCI in both inter-slot repetition and intra-slot repetition.
* Note2: The alternatives are clarified as below,
	+ inter-slot repetition: One PUCCH resource carries UCI , another one or more PUCCH resources or the same PUCCH resource in another one or more slots carries a repetition of the UCI .
	+ intra-slot repetition: One PUCCH resource carries UCI , another one or more PUCCH resources or the same PUCCH resource in another one or more sub-slots carries a repetition of the UCI
	+ intra-slot beam hopping: UCI is transmitted in one PUCCH resource in which different sets of symbols have different beams

### 103-e (November 2020)

**Agreement**

For multi-TRP PUCCH transmission schemes.

* Support multi-TRP inter-slot repetition (Scheme 1)
	+ One PUCCH resource carries UCI, another PUCCH resource or the same PUCCH resource in another one or more slots carries a repetition of the UCI.
	+ FFS: Number of repetitions
* Further study the support (one or both) of the following schemes
	+ Multi-TRP intra-slot beam hopping (Scheme 2)
		- UCI is transmitted in one PUCCH resource in which different sets of symbols within the PUCCH resource have different beams.
		- FFS: More than 2 beam hopping instances per PUCCH resource.
	+ Multi-TRP intra-slot repetition (Scheme 3)
		- One PUCCH resource carries UCI, another PUCCH resource or the same PUCCH resource in another one or more sub-slots within a slot carries a repetition of the UCI.
* Note1: whether to support two PUCCH resources or the same PUCCH resource with different beams for Scheme 1 and 3 to be discussed separately.

**Agreement**

For multi-TRP PUCCH transmission schemes,

* For Scheme 1, at least PUCCH format 1/3/4 can be used.
* FFS: Support of PUCCH format 0/2 for Scheme 1
* FFS: Support of PUCCH formats for Scheme 2 and/or Scheme 3 (if schemes are agreed).

**Agreement**

For multi-TRP TDM-ed PUCCH transmission schemes,

* Support the use of a single PUCCH resource
* Up to two spatial relation info’s can be activated per PUCCH resource via MAC CE
* FFS: Required enhancements for FR1
* FFS: Use of multiple PUCCH resources.

**Agreement**

For PUCCH multi-TRP enhancements in FR2,

* Support separate power control parameters for different TRP via associating power control parameters via PUCCH spatial relation info.
	+ Note: No spec impact.
* For per TRP closed-loop power control for PUCCH, further study the following alternatives considering TPC command when the “closedLoopIndex” values associated with the two PUCCH spatial relation info’s are not the same.
	+ Option.1: A single 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 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 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.
* FFS: Transition period for beam / power / frequency change.
* FFS: Required power control enhancements for FR1

**Agreement**

For configuration/indication of the number of PUCCH repetitions for Scheme 1, there is no restriction on using Rel-15 framework on configuring the number of repetitions.

* Rel-17 feMIMO may additionally consider supporting the dynamic indication of the number of repetitions in RAN1 #104 meeting.

**Agreement**

For PUCCH multi-TRP enhancements in FR1,

* Support separate power control for different TRP.
* FFS: how to define the association between PUCCH and TRP.
* FFS: required enhancements.

**Working Assumption**

For PUCCH multi-TRP enhancements in Scheme 1, it is possible to configure either cyclic mapping or sequential mapping of spatial relation info’s over PUCCH repetitions.

* FFS: Applicability of mapping patterns for different beam switching gaps
* The support of cyclic mapping can be optional UE feature for the cases when the number of repetitions is larger than 2.
* Note: For Scheme 1, cyclical mapping pattern and sequential mapping pattern are as follows,
	+ Cyclical mapping pattern: the first and second beam are applied to the first and second PUCCH repetition, respectively, and the same beam mapping pattern continues to the remaining PUCCH repetitions.
	+ Sequential mapping pattern: the first beam is applied to the first and second PUCCH repetitions, and the second beam is applied to the third and fourth PUCCH repetitions, and the same beam mapping pattern continues to the remaining PUCCH repetitions.

**Agreement**

LS to RAN4 on beam switching gaps for multi-TRP UL transmission is endorsed in R1-2009807.

### 104-e (February 2021)

**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.

**Working Assumption**

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

1. The same PUCCH resource carrying UCI is repeated for X = 2 [consecutive] sub-slots within a slot.
2. 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)

**Conclusion**

Strive to reuse the specification support for dynamic indication of number of repetitions introduced in the Rel-17 coverage enhancement work item for multi-TRP operation. Decide whether further enhancements for multi-TRP operation are necessary in RAN1#106bis. No further discussion on this topic until RAN1#106bis under agenda item 8.1.

**Agreement**

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

**Agreement**

Further study following alternatives to support per TRP closed-loop power control for PUCCH , select  from the below options 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.

**Working assumption**

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.

### 104-bis-e (April 2021)

**Agreement**

For the case of multi-TRP, to support per-TRP power control in FR1, the linking of PUCCH resource with [one or] two power control parameter sets, the following is supported

* MAC-CE indicates RRC IE that configures power control parameter sets (p0, pathloss RS ID, and a closed-loop index).
	+ The exact design of RRC IE is up to RAN2 but from RAN1 point of view, one possible example is to reuse *PUCCH-SpatialRelationInfo* except for the *referenceSignal*

Note: It is common understanding in RAN1 that one PUCCH resource can be linked to one power control parameter set.

**Conclusion**

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.

**Agreement**

When inter-slot frequency hopping is configured with Scheme 1, decide one from the below options in RAN1#105-e meeting,

* Option 1
	+ If sequential mapping pattern is configured, frequency hopping is performed on slot level (as in Rel-15).
	+ If cyclical mapping pattern is configured, frequency hopping is performed among the repetitions with the same beam.
* Option 2:
	+ gNB always configures sequential mapping pattern and frequency hopping is performed on slot level. (no spec impact)
* Option 3:
	+ Frequency hopping is performed on slot level as in Rel-15 (no spec impact).

**Agreement**

**Confirm the following Working Assumption**:

For PUCCH multi-TRP enhancements in Scheme 1, it is possible to configure either cyclic mapping or sequential mapping of spatial relation info’s over PUCCH repetitions.

* FFS: Applicability of mapping patterns for different beam switching gaps
* The support of cyclic mapping can be optional UE feature for the cases when the number of repetitions is larger than 2.
* Note: For Scheme 1, cyclical mapping pattern and sequential mapping pattern are as follows,
	+ Cyclical mapping pattern: the first and second beam are applied to the first and second PUCCH repetition, respectively, and the same beam mapping pattern continues to the remaining PUCCH repetitions.
	+ Sequential mapping pattern: the first beam is applied to the first and second PUCCH repetitions, and the second beam is applied to the third and fourth PUCCH repetitions, and the same beam mapping pattern continues to the remaining PUCCH repetitions.

**Agreement**

**Confirm the following Working Assumption** (with small correction of typo and clarification on UE capability in RED):

* 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~~ parameter set mapping ~~to sub-slots~~.
	+ The support of cyclic mapping can be optional UE feature for the cases when the number of repetitions is larger than 2.

### 105-e (May 2021)

**Agreement**

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.

**Agreement**

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

* 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.

**Conclusion**

For multi-TRP PUCCH schemes, only one ‘twoPUCCH-PC-AdjustmentStates’ parameter is configured for both TRPs, and the parameter is shared across both TRPs, which means there will be two closed loops in total (no RAN1 spec impact).

**For future meetings:**

Further study the enhancements needed on grouping of PUCCH resources for Rel-17 multi-TRP PUCCH repetition

**Agreement**

* 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).
	+ Each TPC field is for each closed-loop index value respectively
		- FFS: Whether or not the mapping between the TPC field and the PUCCH transmissions is needed
* 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 the closed loop index(es) for the scheduled PUCCH
* 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.
	+ FFS: any additional considerations
* Support UE to report the capability on whether it supports the second TPC field
* Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs.

## 5.2 PUSCH

### 102-e (August 2020)

**Agreement**

For M-TRP PUSCH reliability enhancement, support single DCI based PUSCH transmission/repetition scheme(s).

* Further study multi-DCI based PUSCH transmission/repetition scheme(s) to identify potential gains and required enhancements.
* Note: This agreement does not reflect any prioritization of single DCI based PUSCH transmission/repetition over multi-DCI based PUSCH transmission/repetition. Ran1 can further discuss that in the next meeting.

**Agreement**

For single DCI based M-TRP PUSCH reliability enhancement, support TDMed PUSCH repetition scheme(s) based on Rel-16 PUSCH repetition Type A and Type B.

* Further study PUSCH transmission without repetition as a potential candidate M-TRP PUSCH scheme

**Agreement**

To support single DCI based M-TRP PUSCH repetition scheme(s), up to two beams are supported. RAN1 shall further study the details considering,

1. Codebook based and non-codebook based PUSCH
2. Enhancements on SRI/TPMI/power control parameters/any other

Note1: Companies are encouraged to provide additional details on how above enhancements are applied to different PUSCH repetitions (e.g. mapping between PUSCH repetitions and beams)

Note2: Studying enhancements/aspects related to TA is not precluded.

**Agreement**

Further study M-TRP CG PUSCH reliability enhancements in Rel-17.

**Agreement**

On the mapping between PUSCH repetitions and beams in single DCI based multi-TRP PUSCH repetition Type A and Type B, further study the following,

* For both PUSCH repetition Type A and B, how the beams are mapped to different PUSCH repetitions (or slots/frequency hops),
	+ Alt.1: cyclical mapping pattern (the first and second beam are applied to the first and second PUSCH repetition, respectively, and the same beam mapping pattern continues to the remaining PUSCH repetitions).
	+ Alt.2: sequential mapping pattern (the first beam is applied to the first and second PUSCH repetitions, and the second beam is applied to the third and fourth PUSCH repetitions, and the same beam mapping pattern continues to the remaining PUSCH repetitions).
	+ Alt.3: Half-Half pattern (the first beam is applied to the first half of PUSCH repetitions, and the second beam is applied to the second half of PUSCH repetitions)
	+ Alt.~~3~~4: Other variants (e.g. configurable mapping patterns)
	+ Note1: For PUSCH repetition type B, the variants considering slot level beam mapping with the same mapping principals (replacing repetition with slot) in Alt.1/2/3 are also included.
	+ Note2: For PUSCH repetition type A and B with frequency hopping, the variants considering frequency hop level beam mapping with the same mapping principals (replacing repetition with frequency hop) in Alt.1/2/3 can also be studied further. Final selection of such schemes also depends on the number of beams allowed per PUSCH repetition.
* For PUSCH repetition Type B, which repetition type that the beams shall consider for the mapping,
	+ Alt.1: beams are mapped to the nominal repetitions
	+ Alt.2: beams are mapped to the actual repetitions
	+ Alt.3: beams are mapped to different slots (not in the granularity of actual/nominal repetition)
	+ Alt.4: Other variants
* Consider additional requirements on switching gap(s) between two PUSCH repetitions towards different TRPs considering beam switching latency aspects.
* Note: use of the above solutions to multi-DCI based PUSCH repetition and TDMed PUSCH transmission without repetition (when there are agreed to support) is not precluded.

### 103-e (November 2020)

**Agreement**

For single DCI based M-TRP PUSCH repetition schemes, support codebook based PUSCH transmission with following enhancements.

* Support the indication of two SRIs.
	+ Alt1: Bit field of SRI shall be enhanced.
	+ Alt2: No changes on SRI field
* Support the indication of two TPMIs.
	+ The same number of layers are applied for both TPMIs if two TPMIs are indicated
	+ The number of SRS ports between two TRPs should be same.
	+ FFS: Details on indicating two TPMIs (e.g, one TPMI field or two TPMI fields)
* Increase the maximum number of SRS resource sets to two
* FFS: configuration details of each SRS resource set (e.g., number of SRS resources in a resource set)

**Agreement**

For single DCI based M-TRP PUSCH repetition schemes, support non-codebook based PUSCH transmission with following considerations.

* Increase the maximum number of SRS resource sets to two, and associated CSI-RS resource can be configured per SRS resource set.
* FFS: Enhancements on SRI field in DCI to indicate the two beams for repetitions

**Agreement**

For single DCI based M-TRP PUSCH repetition Type B, at least nominal repetitions are used to map beams

* Further study details and applicability of each mapping method
* Further study the slot based beam mapping in the cases of nominal repetition across slot boundaries

**Agreement**

For PUSCH multi-TRP enhancements,

* For per TRP closed-loop power control for PUSCH, further study the following alternatives when the “closedLoopIndex” values are different.
	+ Option.1: A single 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 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 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.
* FFS: Transition period for beam / power / frequency change.

**Agreement**

Support both type 1 and type 2 CG PUSCH transmission towards MTRP. Further study the following alternatives,

* Alt.1 : single CG configuration
	+ Repetitions of a TB transmitted towards MTPR on multiple PUSCH transmission occasions of single CG configuration.
	+ At least for codebook-based CG PUSCH, support configuring 2 SRIs/TPMIs.
* Alt.2 : multiple CG configurations
	+ Repetitions of a TB transmitted towards MTRP on more than one PUSCH transmission occasions, where one or more transmission occasions are from one CG configuration and another one or more PUSCH transmission occasions are from another CG configuration.
	+ 1 SRI/TPMI is configured/indicated for each CG configuration.
* Further study required beam mapping principals, low overhead mechanisms for beam selection, and other enhancements for Alt.1 and Alt.2.

**Agreement**

For M-TRP PUSCH reliability enhancement, further discuss multi-DCI based PUSCH transmission/repetition scheme(s) considering the following aspects.

* The same TB is repeated towards multiple TRPs with different beams, where one or more PUSCH repetitions are scheduled by one DCI and another one or more PUSCH repetitions are scheduled by another DCI.
* FFS: Details related to timeline restrictions and beam mapping
* Changes on Rel-15/16 MCS, TBS determination, and UL resource allocation are not expected from this scheme.
* The scheme is considered to be supported only if there are gains over single DCI based PUSCH repetition schemes and a similar scheme is not supported by m-TRP PDCCH (e.g. Option 3).

Companies are encouraged to provide simulation results to decide the support of the scheme in next RAN1 meetings

The support of multi-DCI based PUSCH transmission/repetition scheme(s) in Rel-17 will be decided in RAN1#104-e

**Agreement**

For single DCI based PUSCH multi-TRP enhancements, support the following RV mapping for PUSCH repetition Type A,

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

**Agreement**

For single DCI based M-TRP PUSCH repetition Type A and B, further study required enhancements on PTRS-DMRS association.

**Working Assumption**

For single DCI based M-TRP PUSCH repetition Type A and B, it is possible to configure either cyclic mapping or sequential mapping of UL beams.

* The support of cyclic mapping can be optional UE feature for the cases when the number of repetitions is larger than 2.
* FFS: Support of half-half mapping.
* FFS: Additional considerations on mapping patterns (including required beam switching gaps)
* Companies are encouraged to provide further simulation results to decide details.

**Agreement**

LS to RAN4 on beam switching gaps for multi-TRP UL transmission is endorsed in R1-2009807.

### 104-e (February 2021)

**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 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*, and select 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.

**Agreement**

For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,

* Support two SRI fields corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.
	+ 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: Support dynamic switching the order of two TRPs

**Agreement**

For single DCI based M-TRP PUSCH Type B repetition schemes,

* For maxRank = 2, the number of bits for the indication of PTRS-DMRS association is the same as Rel-15/16, MSB and LSB separately indicating the association between PTRS port and DMRS port for two TRPs.
* FFS: the indication of PTRS-DMRS association for maxRank > 2.

**Agreement**

For s-DCI based multi-TRP PUSCH repetition Type A and B, if the DCI schedules A-CSI, support multiplexing A-CSI on the first PUSCH repetition corresponding to the first beam and the X-th PUSCH repetition corresponding to the second beam.

* For PUSCH repetition Type A, X=1 (the first PUSCH repetition corresponding to the second beam)
* For PUSCH repetition Type B, the first actual PUSCH repetition corresponding to the first beam and the X-th actual repetition corresponding to the second beam are considered,
	+ The UE does not expect the first actual repetition corresponding to the first beam and the X-th actual repetition corresponding to the second beam to have a single symbol duration (similar restriction as in Rel-16 NR for the single TRP case).
	+ The first actual repetition corresponding to the first beam and the X-th actual repetition corresponding to the second beam are expected to have the same number of symbols
	+ FFS: X = 1 or X = the first actual repetition corresponding to the second beam that contains the same number of symbols as the first actual repetition with the first beam
* FFS: Any further restrictions/enhancements needed on supporting A-CSI multiplexing on PUSCH repetitions
* FFS: whether to support multiplexing SP-CSI/P-CSI on PUSCH repetitions towards multiple TRPs.

**Agreement**

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

**Agreement**

For single DCI based M-TRP PUSCH repetition schemes, in codebook based PUSCH,

* Two TPMI fields are indicated in DCI formats 0\_1/0\_2.
	+ 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 contains~~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
	+ FFS: Interpreting TPMI fields when multi-TRP and single-TRP PUSCH repetition is applied.
* FFS: whether to support of PUSCH repetitions transmitting towards two TRPs sharing the same TPMI indicated by a TPMI field.
* FFS: The size of the second TPMI field can be equal to or smaller than the size of the first TPMI field

**Agreement**

For single DCI based M-TRP PUSCH repetition schemes, in non-codebook based PUSCH,

* Support two SRI field(s) corresponding to two SRS resource sets are included in DCI formats 0\_1/0\_2.
	+ Each SRI field indicating SRI per TRP, where the first SRI field based on Rel-15/16 framework,
	+ Support the same number of layers applied over repetitions
	+ 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
	+ FFS: whether/how to use SRI field(s) and 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.
* FFS: Support dynamic switching the order of two TRPs
* Companies are encouraged to provide total payload size of the two SRI fields and scheduling restriction, if any

**Agreement**

Further study following alternatives to support per TRP closed-loop power control for PUSCH , select from the below options 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.

### 104-bis-e (April 2021)

**Agreement**

When SRS resources from two SRS resource sets indicated in DCI format 0\_1/0\_2, for linking SRI fields to two power control parameters, it is up to RAN2 to finalize the RRC details related to linking. RAN1 identified that the following options could be used.

* Alt. 1: Add second *sri-PUSCH-MappingToAddModList*, and select 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

**Agreement**

For PHR reporting related to M-TRP PUSCH repetition, select one from the following options in RAN1 #105-e meeting.

* Option 1:  Calculate one PHR associated with the first PUSCH occasion (earliest repetition that overlaps with the first slot in which the PUSCH that carries the PHR MAC-CE is transmitted)
* 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.
* Option 4: Calculate two PHRs, each associated with a first PUSCH occasion to each TRP, and report two PHRs
* Option 5: No changes to legacy PHR reporting

**Agreement**

When MAC-CE indicates a PL-RS ID for one or more SRI IDs, it also indicates whether the SRI IDs are associated with the first or the second SRS resource set.

**Agreement**

For multiplexing A-CSI on two PUSCH repetitions in the case of multi-TRP PUSCH repetition,

* For S-DCI based multi-TRP PUSCH repetition Type B, support multiplexing A-CSI on the first PUSCH repetition corresponding to the first beam and the first (X = 1) PUSCH repetition corresponding to the second beam.
	+ The UE is expected to follow the above operation for multiplexing A-CSI on two PUSCH repetitions only if
		- the first actual repetition corresponding to the first beam and the first actual repetition corresponding to the second beam have the same number of symbols, and
		- 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.
* The content for the two A-CSI should be the same
* Note: RAN1 has the assumption on CSI timelines are followed as rel-15/16, including UE shall expect the timeline for the first A-CSI meets Z and Z’ requirement
* FFS: For s-DCI based multi-TRP PUSCH repetition Type A and B, support multiplexing of 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 is 2 regardless of the indicated number of repetitions.
	+ 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).

**Working Assumption**

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
	+ FFS: Whether the new field is 1 bit or 2 bits

**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.

**Agreement**

For the indication of open-loop power control parameter (OLPC) in DCI format 0\_1/0\_2, support enhanced open-loop power control parameter (OLPC) set indication by indicating per-TRP OLPC set.

* FFS: Details of indication.

**Agreement**

For CB based M-TRP PUSCH repetition, the first TPMI field is used to determine the entry of the second TPMI field which only contains TPMIs corresponding to the indicated rank (number of layers) of the first TPMI field. The second TPMI field’s bit width, *M2*, is determined by the maximum number of TPMIs per rank among all ranks associated with the first TPMI field. For each rank y, the first *Ky* codepoint(s) of the second TPMI field are mapped to *Ky* TPMI(s) of rank y associated with the first TPMI field in increasing order codepoint index, the remaining (2M2-*Ky*) codepoint(s) are reserved.

* How to describe/capture this in 38.212 is up to the editor.

**Agreement**

**Confirm the following working assumption** (with removing the last bullet):

For single DCI based M-TRP PUSCH repetition Type A and B, it is possible to configure either cyclic mapping or sequential mapping of UL beams.

* The support of cyclic mapping can be optional UE feature for the cases when the number of repetitions is larger than 2.
* FFS: Support of half-half mapping.
* FFS: Additional considerations on mapping patterns (including required beam switching gaps)

**Agreement**

For single DCI based M-TRP PUSCH Type B repetition, the indication of PTRS-DMRS association for maxRank > 2 is supported, down select one of the following options in RAN1 #105-e meeting,

* The support of cyclic mapping can be optional UE feature for the cases when the number of repetitions is larger than 2.
* Option 1 (4 bits): with a second PTRS-DMRS association field (similar to the existing field), and each field separately indicating the association between PTRS port and DMRS port for two TRPs.
* Option 2 (2 bits): using the existing PTRS-DMRS association field in DCI for the first TRP, and using reserved entries/bits in DM-RS port indication field for the second TRP.
* 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.

**Agreement**

For type 1 or type 2 CG based multi-TRP PUSCH repetition,

* Introduce the second fields of *'p0-PUSCH-Alpha*' and '*powerControlLoopToUse*' in '*ConfiguredGrantConfig*’
* For type 1 CG based m-TRP PUSCH repetition, introduce the second fields of ‘*pathlossReferenceIndex*’, *'srs-ResourceIndicator*' and '*precodingAndNumberOfLayers*' in *'rrc-ConfiguredUplinkGrant*'.
* For type 2 CG based M-TRP PUSCH, two SRIs/TPMIs are indicated via the activating DCI.
* FFS1: UL PT-RS port(s) and DM-RS port(s) for CG type 1
* FFS3: Details on RV mapping.
* FFS4: Possible transmission occasion for initial transmission
* FFS5: Other TRP specific parameters in '*rrc-ConfiguredUplinkGrant*', e.g., *'dmrs-SeqInitialization*'.

### 105-e (May 2021)

**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 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 is 2 regardless of the indicated number of repetitions.
* The UE is expected to follow the above operation for 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 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.

**Agreement**

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.

**Agreement**

The following working assumption is confirmed.

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.

**Agreement**

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.

**Agreement**

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

**Agreement**

For the new field in the DCI for dynamic switching, support Alt.1 (modified).

**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 set2nd 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: FFS2nd SRI/TPMI field: FFS | 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.
	+ For codebook and non-codebook usage, respectively
* ~~The same number of SRS resource shall be configured in the two SRS resource sets.~~

**Agreement**

For SP-CSI report on mTRP PUSCH repetition Type A and B activated by a DCI, further study the use of a similar mechanism to A-CSI multiplexing on M-TRP PUSCH without a TB, which includes the following,

* When SP-CSI multiplexed on m-TRP PUSCH, SP-CSI multiplexed on the two repetitions associated with the two TRPs, and the number of repetitions is always assumed to be 2, regardless of the value indicated.
* Reuse similar conditions (e.g. UCIs other than the A-CSI are not multiplexed, same number for first actual repetitions, the content of the CSI is the same) to support SP-CSI multiplexing on m-TRP PUSCH as defined in A-CSI multiplexing on M-TRP PUSCH.

**Agreement**

* 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).
	+ Each TPC field is for each closed-loop index value respectively
		- FFS: Whether or not the mapping between the TPC field and the PUCCH transmissions is needed
* 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 the closed loop index(es) for the scheduled PUCCH
* 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.
	+ FFS: any additional considerations
* Support UE to report the capability on whether it supports the second TPC field
* Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs.

**Agreement**

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 in RAN1 #106-e meeting,

* 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 signaling 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 if  *twoPUSCH-PC-AdjustmentStates* is configured, *l*=0 otherwise } can be used for TRP2.
	+ Note: How to design the signaling link sri-PUSCH-PowerControl with two SRS resource sets is up to RAN2.
* 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  *twoPUSCH-PC-AdjustmentStates* is configured, *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  *twoPUSCH-PC-AdjustmentStates* is configured, *l*=0 otherwise } can be used for TRP2.
	+ Note: How to design the signaling link sri-PUSCH-PowerControl with two SRS resource sets is up to RAN2.

**For further study in future meetings:**

For PHR reporting related to M-TRP PUSCH repetition, study following aspects related to option 4,

* Option 4: Calculate two PHRs (at least corresponding to the CC that applies m-TRP PUSCH repetitions), each associated with a first PUSCH occasion to each TRP, and report two PHRs.
* FFS1: How the PHRs are calculated for reporting (actual PHR or virtual PHR)
* FFS2: How the PHRs are calculated for reporting for other CCs if the multi-cell PHR MAC CE is applied.
* FFS3: Required changes to triggering conditions including the required higher layer parameters (e.g.,’phr-PeriodicTimer’, ‘phr-ProhibitTimer’, ‘phr-Tx-PowerFactorChange’ as TRP specific).
* FFS4: Report P-MPR and MPE per TRP within the same MAC-CE extension.

Note: Down-selection between Options 1-5 will be based on this study as well as the trade-off between benefit versus UE complexity.