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

e-Meeting, May 19th – May 27th, 2021

**Agenda item: 8.1.2.1**

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

**Title: Summary #1 of Multi-TRP PUCCH and PUSCH Enhancements**

**Document for: Discussion and Decision**

# Introduction

The Rel-17 work item for enhancements on MIMO for NR includes an objective to extend specification support for enhancements on multi-TRP/panel transmission. In RAN #86, the objectives were agreed to read as follows:

*Enhancement on the support for multi-TRP deployment, targeting both FR1 and FR2:*

* 1. *Identify and specify features to improve reliability and robustness for channels other than PDSCH (that is, PDCCH, PUSCH, and PUCCH) using multi-TRP and/or multi-panel, with Rel.16 reliability features as the baseline*

In this document, proposals on the reliability and robustness improvements for PUCCH and PUSCH are summarized in section 2 and 3. The agreements reached in previous RAN1 meetings are provided in Section 5.

Latest proposals are in yellow.

FL update is in blue.

Offline agreement purple.

# 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 Summary

|  |  |  |
| --- | --- | --- |
| **Issue** | **Summary from Tdocs** | **Moderator comments** |
| #1. PUCCH Power Control: *TPC command* | Please refer FL summaries on RAN1 #104e, and 104-bis-e. | * Company views are diverging, similar to the last two RAN1 meetings. * The FL proposal from the last meeting is proposed again with the final round of comments from few objecting companies. * PUSCH TPC command proposal also included within the same discussion.   See FL proposal 2.1. |
| #2: Default beam for PUSCH | * When PUCCH resource with the lowest ID having two spatial relation info, selects the one with lower ID : **SS**, **QC**, **DCM**, **ZTE, vivo**, **Lenovo**, **CATT, CMCC, Oppo, Apple** * PUCCH resource with the lowest ID cannot be activated with two spatial relation info: **QC**, **CAICT**, **Lenovo** * No issue to define anything in the specs – **E///** | We discussed this during the last RAN1 meeting. There is a majority of support for defining UE behaviour in the specs.  See FL proposal 2.2 |
| #3: Mapping pattern: number of repetitions = 2 | The two transmission occasions are associated with two TRPs respectively, regardless of the configured beam mapping pattern – **CATT, vivo, Nokia, Mtek** | When the number of repetitions = 2, the sequential mapping (RRC configured) does not allow repetition towards multiple TRPs. This proposal can be generalized with PUSCH discussions.  See FL proposal 2.3 |
| #4: Mapping pattern: scheme 1 with Frequency hopping | * Option 1: (12) **Lenovo, CATT**, **CMCC**, **QC**, **CAICT**, **Fujitsu**, **Apple**, **Xiaomi**, **Convida, LG, E///, SS** * Option 2**:** (1) **MediaTek** * Option 3: (8) **HW, IDC, vivo, Spreadtrum**, **OPPO**, **Intel, MediaTek**, **Nokia** | The majority supports option 1.  See FL proposal 2.4 |
| #5: Scheme 3: working assumption | Confirm the working assumption supporting Scheme 3 – **Vivo,** **Nokia**  Non-consecutive sub-slots are used for repetition – **Nokia, Xiaomi** | RAN1 has a pending issue “consecutive” in the following working assumption.  **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.  This was also discussed in the last meeting, but few concerns raised, such as better to wait for IIoT discussion. With the RAN1 TU allocations, it seems IIoT will only resume sub-slot discussions in the August 2021 meeting and feMIMO have to at least decide on removing brackets (on consecutive) or decide how the non-consecutive sub-slot repetition work. This discussion does not require IIoT inputs.  See FL proposal 2.5 |
| #6: Mapping pattern: Other details | * RAN1 supports configurable beam switching gaps – **IDC, Xiaomi** * Introduce beam/power switching gap between two PUCCH TDMed repetitions considering panel activation delay - **LG** * Support dynamic switching between cyclic mapping and sequency mapping based on DCI (with regard to unavailable slots/symbols for uplink transmission) – **Apple, Nokia, APT** | Based on the conclusion related to the beam switching gap in the last RAN1 meeting, there was no consensus to define any switching gaps, and no inputs from others to change the opinion in RAN1.  Three companies suggest discussing dynamic switching of mapping pattern, and FL have not had a proposal on this before. See FL Question 2.6 |
| #7: Scheme 1/3: Repetition numbers | For Scheme 1:  For PUCCH formats 1/3/4: 16 **(CATT, E///**)  For PUCCH format 0/2:   * larger than 2 (**E///**) * 4, 8, and 16 (**E///)**   For Scheme 3:   * X = 2, 4, 8 – **Nokia** * X=2**,** no other values -**Xiaomi** | This was discussed with no agreement last time. Very limited inputs this time. No FL proposal. |
| #8: Scheme 1/3: Other issues | * TRP specific 'initialCyclicShift' of PUCCH Format 0, 'initialCyclicShift' and 'timeDomainOCC' of PUCCH Format 1, 'dataScramblingIdentityPUSCH' of PUCCH Formats 2, 3 and 4. – **ZTE** * Support dynamic switching between the different multi-TRP PUCCH schemes. - **Nokia** | See FL Question 2.7 and Question 2.8. |
| #9: M-TRP intra slot beam hopping (Scheme 2) | Support Scheme 2:   * Yes: **LG, vivo, ZTE Fujitsu, Xiaomi, ZTE, Huawei** * No: **Spreadtrum, Covinda** | This was discussed in multiple meetings. No consensus even in the last meeting. No FL proposal. |
| #10: PUCCH grouping | * PUCCH group configured for updating spatial relation info can be utilized to link power control parameter sets to a group of PUCCH resources simultaneously. - **vivo** * Support PUCCH group based spatial relation update for Rel-17 MTRP PUCCH repetition scheme - **ZTE** * Support that one PUCCH resource can be configured in two PUCCH Groups which correspond to two beams/TRPs in FR2. - **ZTE** | Two companies suggest discussing PUCCH grouping. But minimal inputs even with a FFS item last time. No FL proposal. |
| #11: Handling of overlapping PUCCHs | Rel-15 collision handling is also applied for M-TRP schemes – **E///**  Only the first PUCCH considered when intra-slot PUCCH repetitions overlap with a same PUCCH in multiple sub-slots – **TCL** | FL perspective, these are not essential and can be handled later (if many other companies thinking in the same direction) |

## 2.2 Feature lead Proposals

### Proposal 2.1: Power control TPC

**[Draft for offline] Proposal 2.1:**

* To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2, a second TPC field can be configured via RRC.
* When the second field is configured by RRC , a second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2 (option 3).
* When the second field is not configured by RRC ,  a single TPC field (the existing TPC field) is used in DCI formats 1\_1 / 1\_2, and the TPC value applied for both PUCCH beams.
* To support per TRP closed-loop power control for PUSCH with DCI formats 0\_1 / 0\_2, adopt the same solution as with M-TRP PUCCH schemes.
* Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs.
* Note2: UE capability related to the above can be discussed in the UE feature discussions.

Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | We suggest we list original 4 options and discuss this issue online. We failed to reach consensus from offline discussion in multiple meetings. We still think option 3 is the worst solution compared to other options.  [Mod]: Online time is limited in this meeting, so let’s not entirely rely on. Also, different versions were tried offline during the last three meetings, and option 3 had a clear majority.  As you are aware, this version is addressing suggestions from Apple and HW during RAN1 #104-bis meeting (on the last day), which we could not check with the other companies. Let’s try to have constructive changes than restarting the discussion from scratch. |
| MediaTek | Support |
| QC | We generally support the FL proposal. In our view, this is a compromise based on the status of discussions so far. |
| Lenovo&MotM | Support. |
| CMCC | Support in principle. |
| OPPO | Share similar view as Apple. Clear benefit cannot be observed through adding a second TPC field for optimization of power control. Our first preference is Option 4. However, if majority companies support this proposal, we can accept it for sake of progress.  [Mod]: thanks for compromising, as this was discussed multiple rounds. |
| Samsung | Support FL’s proposal. |
| Vivo | Our preference is Option 3.  We also would like to clarify whether the presence of the second TPC field for PUCCH is for both DCI formats 1\_1 and 1\_2 or DCI format-specific.  [Mod]: RRC configurations can be DCI specific. This is usual practice for DCI 1\_2/0\_2, but we can discuss RRC details later. |
| ZTE | Support FL’s proposal in principle.  Regarding the main bullet, it should be more accurate to say “a second TPC field can be derived from RRC”, rather than RRC configuration. Noted that the need of two TPC values actually depends on two different closed loop indices. That is, once a PUCCH resource is associated with two closed loop indices in PUCCH resource set, the second TPC should be present in DCI.  Similarly when MTRP PUSCH, the need of 2nd TPC commands depends on whether closed loop indices towards two TRPs are different. That means once any two SRS resources in two SRS resource sets are configured with different closed loop indices, the second TPC field should should be present in DCI. Besides, it is natural to allow that two SRS resources in two SRS resource sets are configured with the same closed loop index.  Given that even though all PUCCH/PUSCH repetitions with two beams are configured with one same closed loop index, two TPC fields can be present in DCI. In such case, how to associate the single closed loop index and two TPC fields should be clarified.  Based on the above comment, we suggest to modify this proposal as below:  [Draft for offline] Proposal 2.1:   * To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2, a second TPC field can be derived from RRC. * When the second field can be derived from RRC , a second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2 (option 3). * When the second field cannot be derived from RRC ,  a single TPC field (the existing TPC field) is used in DCI formats 1\_1 / 1\_2, and the TPC value applied for both PUCCH beams. * To support per TRP closed-loop power control for PUSCH with DCI formats 0\_1 / 0\_2, adopt the same solution as with M-TRP PUCCH schemes. * Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs. * Note2: UE capability related to the above can be discussed in the UE feature discussions. * Note3: For MTRP PUCCH, once a PUCCH resource is associated with two closed loop indices in PUCCH resource set, the second TPC field can be derived from RRC and should be present in DCI. For MTRP PUSCH, once any two SRS resource in two SRS resource sets are configured with two closed loop indices, the second TPC field can be derived from RRC and should be present in DCI.   FFS: How to associated one single closed loop index with two TPC fields when the “closedLoopIndex” values are the same for TRPs.  [Mod]: RRC reused or not is the not the essential discussion here. Also, Note3 only seems to detail one assumption of RRC reusing. ‘configuring via RRC’ does not say that it will be a new RRC. So RAN1 can discuss that when we suggest new RRC lists to RAN2. |
| InterDigital | Our preference is Option 3, but we support FL’s proposal as a good compromise. |
| LG | Our preference is Option 3, but we are fine with FL’s proposal as a good compromise. |
| NEC | Support the proposal. |
| TCL | Support FL’s proposal in principle. |
| Xiaomi | Our preference is Option 3, but compared to the solution above, a compromise between Option 3 and Option 4 suggested as a configurable solution as below is more preferred to us,  [Draft for offline] Proposal 2.1:   * To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2, a second TPC field can be configured via RRC. * When the second field is configured by RRC , a second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2 (option 3). * When the second field is not configured by RRC ,   A single TPC field is used in DCI formats 1\_1 / 1\_2, and indicates two TPC values applied to two PUSCH beams, respectively. * To support per TRP closed-loop power control for PUSCH with DCI formats 0\_1 / 0\_2, adopt the same solution as with M-TRP PUCCH schemes. * Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs. * Note2: UE capability related to the above can be discussed in the UE feature discussions.   [Mod] I tried your suggestion before, and a large number of objections were raised. The current version was supported by almost all (other than HW) during the last meeting. |
| Huawei, HiSilicon | We prefer option 2 as it costs less DCI overhead and still support separate power control per TRP. If two bits are used for dynamic switching between sTRP and mTRP, then the TPC can be applied to the first beam indicated by the dynamic switching field.  If majority view is not on this direction, we would prefer option 3, as we don’t see the usefulness of the second bullet.  [Mod] Thanks for the compromise on Option 3. By “second bullet” you meant “second sub-bullet” ? Option 1 was listed as a tread-off between overhead and flexibility. Also, option 1 seems to be a default mode from many company views as it is the closest option to Rel-15/16. I assume you could live with this as concerns raised during RAN1 #104bis is somewhat addressed in the FL proposal this time. |
| Nokia | Support the proposal, as it is a good compromise between flexibility and overhead. |
| FL update #1 | Some comments are included above to **Apple, ZTE, vivo, Xiaomi, HW.** Please check and have your views so that we can conclude this faster. This was almost agreed with last time. |
| Futurewei | We prefer Option 3, but can also accept another option if the majority view support it. |
| Fujitsu | Support FL’s proposal. |
| NTT Docomo | Support the proposal. |
| Ericsson | Our preference is Option 3. The proposal aims ‘To support per TRP closed-loop power control…’. However, in Option 1, the same TPC value from a single TPC field is applied for both PUCCH beams. Then, Option 1 does not seem to fit under per TRP closed-loop power control (i.e., Option 1 is more related to joint closed loop power control of both TRPs).  As a compromise, we can accept Option 4 when the second TPC field is not configured by RRC. Option 4 had more support than Option 1 based on the company positions captured in a previous FL summary R1-2101784 (company positions copied below).    Mod: I tried option 3 and option 4 combination before. Please check R1-2103845 (third FL summary discussion in the last meeting). FW/QC/LG/DCM/ZTE (wanted option 2, ok with option 1)/Xiaomi, SS/MTek did not like that version. On the other hand, current version was almost agreed during last meeting, but the last concern was from HW. I do not think going back and forth helps now. |
| Apple | We think what Ericsson suggested is reasonable, option 4 has more supporting companies. Current proposal preclude option 4. We think online discussion is needed.  Mod: same comment to E///. I tried option 3 and option 4 combination before. Please check R1-2103845 (third FL summary discussion in the last meeting). FW/QC/LG/DCM/ZTE (wanted option 2, ok with option 1)/Xiaomi, SS/MTek did not like that version. On the other hand, current version was almost agreed during last meeting, but the last concern was from HW. I do not think going back and forth helps now. Online discussion is indeed good, but there may many issue on PUSCH that would require at least some technical debate. So, if there is nothing critically wrong with the proposal you supported last time, we can move-on. |
| Intel | Support the FL proposal |
| FL Update #2 | **Apple and E///,** I have some comment above. |
| CATT | Our preference is Option 3 and option 4, but we are fine with the updated proposal from FL as a compromise. |
| ZTE2 | We still have strong concern on this proposal.  @FL, our intention of Note 3 is to let companies note that whether the second TPC field is present in DCI depends on a PUCCH resource configured with two different closed loop indices in PUCCH resource set, rather than the “closedLoopIndex” values are different for TRPs. For example, even though the “closedLoopIndex” values are same for TRPs, once the PUCCH resource set includes a PUCCH resource configured with two different closed loop indices, the second TPC field should be present in DCI. From our perspective, this issue should be clear in RAN1 at first. Based on the above understanding, we believe the new RRC configuration of the second TPC field is redundant and unnecessary, this consensus in RAN1 should be informed to RAN2, if any.  Mod: The FL proposal does not talk about binding TPC fields to PUCCH resource. DCI size cannot change depending on PUCCH resource indicated by the gNB. The proposal is simple (where DCI field is configured via RRC) and should not be mixed up with whatever you suggest here.  Regarding the wording “is configured by RRC”, it seems like the second TPC field is indicated by one (new) RRC signalling directly. If so, as per the first sub-bullet, when all PUCCH resources in PUCCH resource set solely associated with one closed loop index even two spatial relations, why the second TPC field need to be configured by RRC?  Mod: As mentioned, you are suggesting a something else that binding PUCCH resources and DCI fields. RRC fields can be configured via new RRC as a simple solution without always complicating things.  As per the second sub-bullet, once a PUCCH resource in PUCCH resource set associated with two closed loop indices, why the second TPC field should not be present based on the RRC configuration? It can be seen that whether the second TPC field is present can be derived from some related RRC configuration, i.e. the number of closed loop indices of PUCCH resource in PUCCH resource set. To avoid any ambiguity, it makes sense to replace the wording “is configured by RRC” by “can be derived from RRC” in Proposal 2.1.  Mod: Same comment as before.  Regarding the FFS we added before, note that there can be two TPC fields in DCI as well as a same value of “closedLoopIndex” (which means only one TPC value need to be indicated) for TRPs. In such case, how to associate the single closed loop index and two TPC fields is worth to be further study in RAN1. |
| FL update #3 | ZTE >> Some comments above. I tried to rectify your misunderstanding in the below update.  **[Draft for offline] Proposal 2.1:**   * To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2, a second TPC field can be configured via RRC. * When the second field is configured by RRC , a second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2 (option 3). * When the second field is not configured by RRC ,  a single TPC field (the existing TPC field) is used in DCI formats 1\_1 / 1\_2, and the TPC value applied for both PUCCH beams. * To support per TRP closed-loop power control for PUSCH with DCI formats 0\_1 / 0\_2, adopt the same solution as with M-TRP PUCCH schemes. * Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs. This does not have to any relation to the RRC parameter defining the DCI field size. * Note2: UE capability related to the above can be discussed in the UE feature discussions. |
| ZTE3 | @FL, I’m afraid I fail to see technical reasons that the second TPC field should depend on a new RRC. If I understand correctly, it can be a consensus that the number of TPC fields depends on the number of closed loop indices for MTRP PUCCH scheme, which means same closed loop index corresponding to one TPC field, different closed loop indices corresponding to two TPC fields. Meanwhile, once a PUCCH resource is configured with two closed loop indices in the configured PUCCH resource set, the second TPC field should always be present in DCI. Feedback to your comment that “DCI size cannot change depending on PUCCH resource indicated by the gNB”, my previous elaborations wanna clarify DCI size/ the second TPC field should depend on the configuration of PUCCH resource set, instead of PUCCH resource. It doesn’t mean to change the DCI size via PUCCH resource selection, but to determine the DCI size. Therefore, it can be more accurate to say “the second TPC field can be derived from RRC (configuration for PUCCH resource set)” based on technical perspective, plus the new RRC is redundant and unnecessary.  Mod: As commented by few companies, the suggested dependency on DCI fields with PUCCH resource set configuration. |
| Fujitsu | Support FL’s proposal.  The proposal from ZTE seems unclear us. Does it mean that for example, in FR2, a number of candidate spatial relations are configured for PUCCH resources, and if those spatial relations include different closed loop indexes, then UE assumes that second TPC field exists? |
| LG | Although ZTE’s proposal is one way of TRP specific TPC enhancement, we support the common design for PUSCH and PUCCH unless there is a critical issue. |
| Apple | We still do not think this is a good approach after further checking. The first issue is that the indication would always leave 2 bit overhead although the triggered PUCCH/PUSCH is for sTRP. The second issue is whether the TPC command for another CLI is valid or not if the triggered PUCCH/PUSCH is for sTRP or mTRP with the same CLI.  This proposal with mixed options is friendy to gNB, but not friendly to UE. To be fair UE capability should be introduced to select the UE preferred solution.  Mod: First issue of DCI overhead is indeed there. To my understanding, that is not a big issue for M-TRP UL repetition as motivation for M-TRP mainly comes due to blockage, not to solve coverage limitations. Anyways, that does not give us the freedom to add bits to DCI as we like, and that is why a general view of the group is considered. The majority seems to be ok with it.  The second issue you mentioned is related to TPC command field applicability. To my understanding, a field validity depends on the number spatial relation info (for PUCCH) and DCI field on S-TRP/M-TRP switch (for PUSCH). This should be further discussed regardless we agree on option 1, 2, 3, or 4. Hard to see that only valid for option 3 and 1.  On the gNB friendly or UE friendly, it is not the correct interpretation of the direction of the proposal. The TPC commands are anyways for the network to control the UL power of the UE, and it is already a gNB friendly feature. The UE capability is mentioned in the FL proposal.  If you really have further concerns, please convince others of another option. |
| Ericsson | @FL: For the sake of progress, we can accept the latest FL proposal.  Regarding ZTE’s proposal, we do not think the presence of the second TPC field needs to be tiled to PUCCH configuration. Using a dedication RRC parameter is a cleaner solution.  On per TRP closed-loop power control, we’d like to clarify one thing regarding closed-loop index configuration. For mTRP PUCCH, which of the following two assumptions do we make here?   1. a common RRC configuration for both TRPs:   twoPUCCH-PC-AdjustmentStates        ENUMERATED {twoStates}   or   1. “twoPUCCH-PC-AdjustmentStates” is separately configured per TRP   In case of (a) , up to 2 closed-loops can be configured for mTRP and a same closed-loop may be configured for both TRPs. In case of (b), up to 2 closed-loops are supported per TRP, and up to 4 closed-loops in total may be configured, different closed-loops are always used for different TRPs even if a same closed-loop index value is configured. This is more for improving common understanding, and this doesn’t have to be captured in the proposal above.  Mod: At least on PUSCH, we tried a proposal in R1-2103844 (Proposal 3.2-3), but companies did not like to discuss it further. I think companies think on option (a) you mentioned, so no enhancement is needed. |
| OPPO | Compared to ZTE’s proposal, FL’s proposal can offer more flexibility to gNB. Thus, FL’s proposal seems more friendly to gNB vendor. |
| FL Update #4 | Added few comments on Apple, ZTE and E///  @All >> As we have a good amount of discussion so far, please list your objections on the following.  **If you object, please also state the proposal you wish to discuss and use this tread to convince others.**  **Proposal 2.1:**   * To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2, a second TPC field can be configured via RRC. * When the second field is configured by RRC , a second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2 (option 3). * When the second field is not configured by RRC ,  a single TPC field (the existing TPC field) is used in DCI formats 1\_1 / 1\_2, and the TPC value applied for both PUCCH beams. * To support per TRP closed-loop power control for PUSCH with DCI formats 0\_1 / 0\_2, adopt the same solution as with M-TRP PUCCH schemes. * Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs. This does not have to any relation to the RRC parameter defining the DCI field size. * Note2: UE capability related to the above can be discussed in the UE feature discussions. |
| vivo4 | FL’s proposal is preferred with minor wording updates:  **Proposal 2.1:**   * To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2, a second TPC field can be configured via RRC. * When the second field is configured by RRC , a second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2 (option 3). * When the second field is not configured by RRC ,  a single TPC field (the existing TPC field) is used in DCI formats 1\_1 / 1\_2, and the TPC value applied for both PUCCH beams. * To support per TRP closed-loop power control for PUSCH with DCI formats 0\_1 / 0\_2, adopt the same solution as with M-TRP PUCCH schemes. * Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs. This does not have ~~to~~ any relation to the RRC parameter ~~defining the DCI field size~~ indicating the presence of the second TPC field. * Note2: UE capability related to the above can be discussed in the UE feature discussions. |
| ZTE4 | As I elaborated before, I hope one case can be noticed by companies that although when two TPC fields are present in DCI format 1\_1 or 1\_2, the PUCCH resource selected by PRI may be activated with single beam corresponding a single closed loop index or may be activated with two beams with the same closed loop index. In such case, how to associate the single closed loop index and two TPC fields should be clarified. Therefore, at least one FFS can be added for further study.  **Proposal 2.1:**   * To support per TRP closed-loop power control for PUCCH with DCI formats 1\_1 / 1\_2, a second TPC field can be configured via RRC. * When the second field is configured by RRC , a second TPC field (similar to the existing TPC field) is added in DCI formats 1\_1 / 1\_2 (option 3). * When the second field is not configured by RRC ,  a single TPC field (the existing TPC field) is used in DCI formats 1\_1 / 1\_2, and the TPC value applied for both PUCCH beams. * To support per TRP closed-loop power control for PUSCH with DCI formats 0\_1 / 0\_2, adopt the same solution as with M-TRP PUCCH schemes. * Note1: Per TRP closed-loop power control is only applicable when the “closedLoopIndex” values are not the same for TRPs. This does not have to any relation to the RRC parameter defining the DCI field size. * Note2: UE capability related to the above can be discussed in the UE feature discussions. * FFS: How to use two TPC fields to indicate one shared TPC value of TRPs when the “closedLoopIndex” values are the same for TRPs. |
| InterDigital | Support FL proposal, similar view as Ericsson that it would be a cleaner design. |

### Proposal 2.2: Default beam for PUSCH

**[Draft for offline] 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.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support |
| MediaTek | Do not support. Since multiple PUCCH resources can be configured and it is unusual that all PUCCH resources have two spatial relation info, it suffices that the PUCCH resource with the lowest ID is always activated with one single spatial relation info.  [Mod] it is true that this can be avoided by network configuration.  But, is not it more beneficial (even it is marginal) not to limit PUCCH resource that can have two spatial relation info ? As this is a straightforward change to the spec, there is no apparent technical/procedural reason to do otherwise. FL thinks we can go ahead with the majority view. |
| QC | Support. We are also fine with agreeing that UE does not expect the PUCCH resource with the lowest ID to be activated with two spatial relation info. |
| Lenovo&MotM | Support. |
| CMCC | Support. |
| OPPO | Support |
| Samsung | Support FL’s proposal. The clarification can make the spec clear and there is no limitation to configure the spatial relation info(s) for all PUCCH resources. |
| Vivo | Support.  We also think the above proposal should apply to both dynamic grant and configured grant. |
| ZTE | Support FL’s proposal. |
| InterDigital | We support FL’s proposal. |
| LG | We have the same view with MediaTek. What is issue with configuring lowest ID PUCCH resource with one spatial relation? gNB can still configure two single spatial relation info for other PUCCH resources than PUCCH resource with lowest ID, if needed.  [Mod] : Please check my reply to Mtek. gNB can off course, configure single spatial relation info. But, as this is not a critical issue for network or Ues, there is no reason to reduce flexibility. Let’s go with the majority view. |
| NEC | Support the proposal. |
| TCL | We support FL’s proposal. |
| Xiaomi | support |
| Fraunhofer IIS/HHI | Support FL’s proposal |
| Huawei, HiSilicon | We share the same view as MediaTek. It can be easily handled by clarification in the spec that UE does not expect the PUCCH resource with lowest ID is activated with two spatial relation info.  [Mod] : Please check my reply to Mtek and LG. |
| Nokia | No strong preference. We can be fine with either the proposal or to have the restriction that ‘UE does not expect the PUCCH resource with lowest ID is activated with two spatial relation info’. |
| FL Update #1 | Comments are added to Mtek, LG and HW.  The majority support the proposal. |
| Futurewei | It seems MediaTek’s solution is better. There is no need to support 2 TRPs for all PUCCH transmissions / every PUCCH resource.  [Mod] MTek is ok with the FL proposal. Supporting 2 spatial relation info for all PUCCH resources or not can be up to netwtok implementation. Spec does not have to limit that right ? |
| Fujitsu | Support FL’s proposal. |
| NTT Docomo | Support the proposal. |
| MediaTek2 | We are OK to go with the majority view.  [Mod] Thanks for the compromise. |
| Ericsson | Similar view as LG, and Huawei. But we are ok with agreeing something along the following lines:  “The UE does not expect the PUCCH resource with the lowest ID to be activated with two spatial relation info’s.”  [Mod]: From network vendor perspective, is not it more beneficial (even it is marginal) not to limit PUCCH resources that can have two spatial relation info ? As this is a straightforward change to the spec, there is no apparent technical/procedural reason to do otherwise. |
| Intel | This is a non-essential issue – gNB can take care of this through implementation (same way PUCCH/PUSCH collision handling is done for mTRP)  [Mod]: the problem would be incorrect interpretations in future without anything stating in the specs. That was highlighted by few companies. As this is a minor issue also in your view, we should not debate on exact method, majority is ok with the current proposal. |
| FL Update #2 | LG, HW, Intel, FW, and E/// to check further.  The majority support the proposal. |
| CATT | We suggest to discuss whether M-TRP repetition for PUSCH scheduled by DCI format 0\_0 can be supported before agree on this proposal.  If M-TRP repetition for PUSCH scheduled by DCI format 0\_0 is supported, the spatial relation of the PUSCH can be determined by the PUCCH resource with the lowest ID   * if the PUCCH resource with the lowest ID is activated with two spatial relation info’s, the number of transmission occasions of the PUSCH is two, and each occasion is associated with one spatial relation info; * otherwise, the number of transmission occasion of the PUSCH transmission is 1, and the spatial relation info with lower ID is used as the default beam for PUSCH scheduled by DCI format 0\_0. |
| ZTE2 | According to the comments input so far, we prefer the proposal raised by CATT, because it is benefit to support MTRP PUSCH scheduled by DCI format 0\_0. |
| FL Update #3 | CATT, ZTE >> CATT suggestion is not relevant to this. We can discuss your suggestion later if majority want to support DCI 0\_0 also for PUSCH repetition (That is not agreed yet).  The proposal is not changed for now.  CATT, LG, HW, Intel, FW, and E/// to check further. |
| ZTE3 | We can be fine to further discuss MTRP PUSCH scheduled by DCI format 0\_0. |
| LG | We don’t support the proposal.  First of all, DCI 0\_0 is fall back DCI and it is reasonable to schedule PDSCH with a basic transmission scheme, instead of MTRP transmission. Secondly, what is issue with limiting one spatial relation info for PUCCH resource with lowest ID? It causes scheduling restriction but we fail to find disadvantage, since gNB still can configure MTRP PUCCH resources other than PUCCH with lowest ID. If there is no issue with this scheduling restriction, then why do we need to define unnecessary UE behavior?  Mod:  First issue you mentioned is not discussed in the proposal.  Second issue, nothing wrong with setting single spatial relation info for the lowest ID PUCCH resource. It is not clear from your reply why that is needed to restrict ? Is there any big technical issue you would like to highlight? |
| OPPO | DCI format 0\_0 is always used in fallback mode. Thus, we don’t think M-TRP operation is needed for DCI format 0\_0 |
| FL Update #4 | Added comment to LG |
| InterDigital | Support FL proposal.  We don’t see that FL proposal would impose “*that all PUCCH resources have two spatial relation info,*”. |

### Proposal 2.3: Number of repetitions equal to two

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

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

Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | We do not know why this proposal is needed. Could proponents clarify the motivation?  [Mod]: Mtek, QC, and vivo provided explanations below. This is the same procedure we used for Rel-16 S-DCI M-TRP scheme 4. |
| MediaTek | Support. @Apple: Without this proposal, sequential mapping applies the same beam to both repetitions and there is no spatial diversity. |
| QC | Ok with the proposal as the number of repetitions can be dynamic (for PUSCH) or can be per PUCCH format / resource (for PUCCH) while the mapping pattern is RRC configured and common to all PUCSH / PUCCH transmissions. |
| Lenovo&MotM | Suppoort. |
| CMCC | Support. |
| OPPO | Support |
| Samsung | Support FL’s proposal. For repetition number = 2, the proposal is natural way to support mTRP transmission. |
| Vivo | Support. When sequential beam mapping pattern is configured for MTRP PUSCH or PUCCH repetition, beam diversity cannot be obtained if only two repetitions are scheduled. So, such behavior for PUSCH/PUCCH shall be specified as MTRP PDSCH, which states the first and second transmission occasion shall be associated with two beams regardless of the configured mapping pattern. |
| ZTE | It equals to half-half beam pattern when repetition number is 2. To give a more explicit picture, it can be when the number of repetitions is equal to two, half-half beam pattern should be configured for MTRP PUCCH (scheme 1 and 3) and PUSCH (Type A and B) repetition schemes.  [Mod] : This is the same procedure defined in the spec for s-DCI M-TRP scheme 4. No need to define any names as that might create confusion. |
| InterDigital | We support FL’s proposal. |
| LG | We support FL’s proposal. |
| NEC | Support the proposal. |
| TCL | We support FL’s proposal. |
| Spreadtrum | Support the proposal. |
| Xiaomi | support |
| Huawei, HiSilicon | We are fine with the proposal. |
| Nokia | Support the FL’s proposal |
| FL update #1 | Added comments to Apple and ZTE  Majority support the proposal. |
| Futurewei | It seems this proposal is to avoid the M-TRP PUCCH degenerates to S-TRP PUCCH repetition. Not sure if this is absolutely needed, but fine with more discussions. |
| Fujitsu | Support FL’s proposal. |
| NTT Docomo | Support. |
| Ericsson | Ok. |
| Apple | OK with the proposal |
| Intel | Ok |
| FL update #2 | Almost all companies ok with the proposal.  **Offline agreement 2.3:** For multi-TRP PUCCH (scheme 1 and 3) and PUSCH (Type A and B) repetition, when the number of repetitions is equal to two, the first and second transmission occasion shall be associated with two TRPs, respectively (two UL beams or Power control parameter sets), regardless of the configured mapping pattern.  • Note: For M-TRP PUSCH type B, the number of repetitions refers to ‘nominal’ repetition. |
| CATT | Support. |
| Convida Wireless | Support |
| ZTE | If majority prefer this proposal, we can be fine with it. |
| Fujitsu | Support |
| Xiaomi | Support |
| FL update #3 | **Offline agreement 2.3:** For multi-TRP PUCCH (scheme 1 and 3) and PUSCH (Type A and B) repetition, when the number of repetitions is equal to two, the first and second transmission occasion shall be associated with two TRPs, respectively (two UL beams or Power control parameter sets), regardless of the configured mapping pattern.  • Note: For M-TRP PUSCH type B, the number of repetitions refers to ‘nominal’ repetition. |

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

**[Draft for offline] Proposal 2.4:** 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 (or power control parameter set).

Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support |
| MediaTek | Do not support. Sequential mapping in combination with inter-slot FH is sufficient. The order of frequency diversity and beam diversity is not essential. |
| QC | Support. The benefit compared to Options 2/3 have been discussed at length before (early termination benefit with both beam and freq. diversity). |
| Lenovo&MotM | Support. And we propose this scheme is reused for PUCCH scheme 3 with inter-sub-slot frequency hopping. |
| CMCC | Support. |
| OPPO | Not support. The additional benefit of this proposal is questionable. We prefer Option 3 as it does not have spec impact. |
| Samsung | Support FL’s proposal. To obtain frequency and spatial domain diversity fully, frequency hopping per beam should be supported. |
| vivo | We don’t support this proposal.  We think there is no need to specify any new frequency hopping behavior.  Firstly, we agree with MeidaTek’s comment that sequential mapping in combination with inter-slot frequency hopping (figure b) is sufficient to achieve both beam hopping gain and frequency diversity gain.  Secondly, there is use case for cyclical beam mapping plus inter-slot frequency hopping (figure a), where the same frequency hop is always mapped to the same beam, so that PUSCH repetitions have a chance to be scheduled on preferred frequency for each beam.  In light of the analysis, we think the legacy frequency hopping behavior performs its merits under different beam mapping patterns.     1. b) |
| ZTE | Support FL’s proposal. If the benefit of option 1 is not clear, we also can live with option 3 which without spec impact. |
| InterDigital | We prefer option 3 to reduce the spec impact. |
| LG | Support FL’s proposal. The proposal provides benefit of early termination compared to sequential mapping + inter-slot frequency hopping. |
| NEC | We prefer option 3. |
| TCL | We prefer option 3 as it does not have spec impact. |
| Spreadtrum | We prefer option 3. |
| Xiaomi | support |
| Huawei, HiSilicon | We do not support. We don’t see the benefits of cyclic mapping pattern with frequency hopping compared with sequential mapping pattern with frequency hopping.  So we prefer option 3. |
| Nokia | Do not support.  We share similar views as MediaTek and vivo. |
| FL update #1 | More companies have concerns and no individual responses.  Companies with concerns: **MediaTek, HW, IDC, vivo, Spreadtrum, OPPO, TCL, NEC, Nokia**  Almost all companies raised the concerns, suggesting Option 3 (Frequency hopping is performed on slot level as in Rel-15 (no spec impact).). FL allow more discussion as there was a slight majority view from Tdoc submissions on option 1. |
| Futurewei | Not sure about the benefit of these “combinations”. Could be very little / marginal. |
| QC2 | @ vivo: In our understanding, the intention is not to preclude the legacy frequency hopping behavior. We can try to clarify this as bellow:  **[Draft for offline] Proposal 2.4:** 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 (or power control parameter set) when this behavior is configured. When this behavior is not configured, frequency hopping is performed on slot level (as in Rel-15).   @ other companies with concern: I assume no one questions the benefit, which is early termination when possible while realizing both beam and frequency diversity eventually. Regarding how essential the enhancement is, I would agree that w/o this enhancement, mTRP PUCCH still works. At the same time, we are not at the maintenance phase yet and also most of the details of PUCCH design are done. So, it is ok to have optimization type of enhacements as long as there is a clear justification. |
| Fujitsu | Support FL’s proposal and also fine with QC’s revision. |
| MediaTek2 | @QC: Can you elaborate why it is benefitial to have early termination, for gNB or for UE? |
| Ericsson | Support FL’s proposal |
| Intel | Agree that this is not essential |
| QC3 | @MediaTek: It is for the system performance. The benefit is opportunistic latency reduction for UL traffic. If the TB can be decoded from the first 2 repetitions (by realizing beam diversity first), gNB does not need to wait for reception of sunsequent repetitions. |
| FL update #2 | Companies can further comment on FL proposal or QC revision. For the moment, we should select only one option rather than complicating a solution with option 1 and 3, so no change on the FL proposal.  As highlighted by QC, this enhancement seems be saving gNB decoding attempts (also depends on how gNB do the decoding). For two repeittins, two beams may be anyways used, regardless the configured pattern based on our earlier discussion.  Companies who raised concerns or not essential**: MediaTek, HW, IDC, vivo, Spreadtrum, OPPO, TCL, NEC, Nokia, FW, Intel**  Further discussion is encouraged. |
| vivo3 | @QC: We are not sure how much benefit of early termination can be achieved by changing the frequency hopping pattern for cyclical beam mapping either.  To understand the early termination when a beam is blocked, we attempt to analyze the some cases assuming a PUCCH can be successfully decoded when receiving the repetitions from two frequency hops on a good beam by utilizing frequency diversity gain.  As shown in figures below, if the first beam is blocked, and termination occurs when frequency diversity is acquired by the second beam, the termination instants of two FH patterns are same; if the second beam is blocked, and termination occurs when frequency diversity is acquired by the first beam, the termination instant of sequential BH + legacy FH is even earlier than that of cyclical beam + new FH.    From the above simple analysis, if frequency diversity gain has to be utilized for success decoding, there is no obvious benefit of early termination with the new FH pattern.  Of course we can investigate more cases and perform some simulation to see the benefit of introducing new FH pattern. |
| CATT | This issue is related to proposal 2.3. If proposal 2.3 is agreed, when sequential mapping is configured and NRep = 2, FH is performed in slot level as shown in Fig. a); when cyclical mapping is configured and NRep = 2, FH is performed within a beam as Fig. b).  To enable FH when NRep = 2, the case shown in Fig. a) is preferred.    So, we suggest to revise the proposal as follows:  When inter-slot frequency hopping is configured with Scheme 1, support the following,   * If the repetition number is larger than 2,   + 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 (or power control parameter set). * Otherwise, frequency hopping is performed on slot level. |
| Convida Wireless | Support FL’s proposal. |
| Fujitsu | The point raised by CATT is worth considering. In our view, this problem can be split into two parts: 1) the applicability of sequential/cyclical mapping pattern; 2) how FH is performed when the NRep = 2.  For the first part, our opinion is that, if proposal 3.2 is agreed, sequential/cyclical mapping pattern is only applicable to the case of NRep > 2. A corresponding note can be added to the FL’s proposal.  For the second part, we are not sure how much gain can be obtained to perform FH across TRPs. |
| LG | @VIVO: Thanks for sharing nice picture. For the case where both of two hops are needed to decode PUCCH successfully, the FL proposal does not provide early termination benefit. However, the benefit comes opportunistically, which means if we consider other case such that gNB successfully decodes PUCCH from first hop of non-blocked beam, early termination benefit can be found. |
| Lenovo&MotM | Support the proposal to obtain the frequency diversity of each link between each TRP and UE. |
| QC | @vivo: I am not sure if I understood your argument. The point is not about realizing freq. diversity earlier. The point is that beam diversity is dominant in the case of blocking. Then, in the Figures you have, termination occurs if at least one repetition with the non-blocked beam is received. This is opportunistic early termination as pointed out by LG, which means that at the end of all repetitions, we benefit from both beam and frequency diversity, but beam diversity is first. |
| OPPO | We share similar view as many companies that the benefit is not clear.  1. It is not clear how much the probability of the early termination is. If gNB indicates UE to transmit X times, it is likely only the total transmissions of X times can achieve the BLER target for most times. Otherwise, gNB’s scheduling will waste the resources.  2. For early termination, more complexity is expected at gNB sides. For example, four channel estimations and decoding will be needed for 4 repetition at the worst case  \* 1st: channel estimation + decoding  \* 2nd: channel estimation + decoding  \* 3rd: channel estimation + decoding  \* 4th: channel estimation + decoding |
| FL Update #3 | Diverging views. We need more discussion on this. Please continue to address the comments raised above. |
| CATT | We prefer to discuss solutions for NRep > 2 and NRep = 2 separately. When NRep = 2, a unique solution should be applied regardless of the configuration of beam mapping pattern since no matter which beam mapping pattern is configured, cyclical mapping is applied. |
| vivo4 | @LG @QC: Thanks for further discussion.  The case as you described terminates early by cyclical beam mapping pattern without frequency diversity gain. So if gNB doesn’t think frequency diversity is necessary to the performance, cyclical beam mapping can be configured with tuning off frequency hopping. If gNB wants to acquire both beam diversity and frequency diversity simultaneously, sequential beam mapping pattern and inter-slot frequency hopping can be configured.  From above analysis, the new frequency hopping pattern can’t bring benefits all the time, so we think the benefit of introducing the new FH pattern is not very solid. |
| InterDigital | Similar view as OPPO; Support Option 3. |

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

**[Draft for offline] Proposal 2.5:** For multi-TRP intra-slot repetition (Scheme 3),

* FFS1: On the support of consecutive or non-consecutive sub-slots, decide one of the following,
  + Alt.1: Consecutive sub-slots are applicable for any sub-slot configuration.
  + Alt.2: Non-consecutive sub-slots are applicable only for 2-symbol sub-slot configuration, where one sub-slot can be skipped between PUCCH repetitions towards different TRPs
  + Alt.3: Non-consecutive sub-slots are applicable for both 2-symbol and 7-symbol sub-slot configuration, where one sub-slot can be skipped between PUCCH repetitions towards different TRPs.
    - Note: two 7-symbol sub-slot repetitions are no longer within a slot.
* FFS2: Confirm the working assumption (*removing brackets on [consecutive] depend on FFS1*).

**Working Assumption**

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

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

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

Please comment on preferred changes to the proposal. Provide inputs on FFS1 and FFS2.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | For FFS1: We suggest to add a Alt as follows:   * Alt4: Whether to support consecutive or non-consecutive sub-slots are based on UE capability   [Mod] : This comment and the suggested Alt 4 is not clear. It seems your suggestion are sub-level discussion related to Alt.2 and Alt.3. |
| MediaTek | For Alt. 2 and Alt.3, we prefer that one sub-slot can be skipped only when the PUCCH resource is of the same number of symbols as the length of subslot. Since a one-symbol gap is sufficient, there is naturally a gap if one repetition does not use all symbols in a subslot.  With the above revision, we support Alt. 2 and support to confirm the working assumption.  [Mod]: It seems your suggestion is mainly on the alt.2. We can add sub-variants of Alt 2 later if the majority selects that. |
| QC | Sub-slot configuration is up to IIoT AI to decide. Furthermore, we concluded in the previous meeting to not introduce gap due to beam switch from RAN1’s perspective. Hence, the sub-slot configuration for single-TRP (to be defined by IioT) can be directly used for mTRP.  [Mod]: IioT will only discuss sub-slot configuration details related to s-TRP repetition. The discussion above is not changing their discussion on the number of repetitions, formats, and others. In eMIMO, we have already a working assumption with a bullet saying, “The same PUCCH resource carrying UCI is repeated for X = 2 [consecutive] sub-slots within a slot.” . The idea of FFS1 is to close this discussion. FL assume you support Alt.1 in FFS1. |
| Lenovo&MotM | For FFS1, we prefer Alt 3. And we also agree with Apple to add the Alt 4.  For FFS2, support to confirm the workassumption. |
| CMCC | For FFS1, we think one symbol gap is sufficient to switch to another beam. For 7-symbol sub-slot configuration, skipping a whole sub-lot might be a little bit wasteful.  Therefore, we support Alt 2 for FFS1 and support to confirm the working assumption. |
| OPPO | Support FL’s proposal |
| Samsung | For FFS1, we can support Alt. 3 with the revision that one sub-slot can be skipped between PUCCH repetitions towards different TRPs if the number of PUCCH symbols is same as the length of sub-slot.  For FFS2, we can support that in principle. Based on FFS1, [consecutive] can be removed and X can be more than 2 (X>2). |
| Vivo | For FFS1, we support Alt1.  For FFS2, we support confirm the working assumption without any modification.  We are wondering that the introducing of non-consecutive sub-slots repetition is for beam switching gap? However, after online extensively discussion, there was no consensus in RAN1 to specify symbol gap(s) for all PUCCH schemes including scheme 3. What’s more, sub-slot based PUCCH is agreed by taking the Rel-16 slot-based PUCCH by replacing with “sub-slot” appropriately without any further enhancement in Rel-17 eIIoT. So, we do not see the necessity of any new pattern design for the intra-slot repetition to keep a unified design.  [Mod]: yes, non-consecutive sub-slots may relate to beam switching gap. That has not had consensus last time. Still, there seems to be a different understanding on the “The same PUCCH resource carrying UCI is repeated for X = 2 [consecutive] sub-slots within a slot.” Which we shall finalize. |
| ZTE | For FFS1, we are supportive of Alt. 1.  For FFS2, we are fine with the confirmation. |
| InterDigital | We share the same view as QC.  [Mod]: See the reply under QC comment. |
| LG | We share the same view as Samsung and also fine with Alt 4 proposed by Apple.  [Mod]: See the reply under Apple comment. |
| NEC | Support Alt 1 for FFS1.  Support to confirm the WA for FFS2. |
| TCL | For FFS1, we support Alt3 as it provides a unified solution for both 2-symbol and 7-symbol sub-slot configuration.  For FFS2, we support in principle and [consecutive] can be removed. |
| Spreadtrum | For FFS1, we prefer Alt1.  For FFS2, we prefer to confirm the WA for FFS2 |
| Xiaomi | For FFS1, we support Alt.2. For 7-symbol case, omitting the first symbol of the allocation related to the second repetition (resource allocation is 6 symbols) would be preferable, thus two 7-symbol sub-slot repetitions can be within a slot.  For FFS2, support to confirm the working assumption. |
| Huawei, HiSilicon | For FFS1, we share the same view as QC. We don’t think there is any difference between sTRP and mTRP sub-slot repetition.  For FFS2, we are fine to confirm it.  [Mod]: See the reply under QC comment. |
| Nokia | Support the proposal in principle.  On FFS1, we support Alt.3. For multi-TRP PUCCH schemes, reusing /relying on the existing RAN4 defined behaviors or similar behaviors (where basically blanking is applied) to account for the required switching gap(s) /transient period(s) would negatively impact the PUCCH reliability at least in some cases, and this goes against the Rel-17 multi-TRP URLLC objectives.  On FFS2, we share the same view as Samsung. |
| Fl update #1 | Different opinions. I added few responses above to Apple, Mtek, QC, viv, IDC, HW, LG.  On FFS1, there is good support on Alt.1 (QC, IDC, vivo, ZTE, NEC, Spreadtrum, HW), while other variants do not have the same number of supporting companies (hard to list as companies propose different flavours).  Similarly, no strong objections on confirming the working assumption.  Proposal 2.5: Confirm the working assumption with removing brackets on [consecutive].  Working Assumption  For PUCCH reliability enhancement, support multi-TRP intra-slot repetition (Scheme 3) for all PUCCH formats.   * The same PUCCH resource carrying UCI is repeated for X = 2 ~~[~~consecutive~~]~~ sub-slots within a slot. * Refer the design details related to sub-slot configurations (e.g. other values of X) to Rel-17 eIIoT   Note1: The decision of supporting scheme 3 is only applicable for multi-TRP operation. |
| Futurewei | Fine with the original proposal and the new proposal. |
| QC2 | We are ok with confirming the WA with removing the brackets on [consecutive]. |
| Fujitsu | Support the updated FL proposal. |
| NTT Docomo | For FFS1, support alt.1.  For FFS2, support to confirm the working assumption. |
| Ericsson | For FFS1, we support Alt1.  Regarding FFS2, we are fine to confirm the working assumption. |
| Apple | For FFS1, to clarify for Alt4, it is not sub-level for Alt2/3, but it is to give UE flexibility.  Mod: My comment was that Alt.4 suggested by you does not say anything about how the non-cosecuitve sub-slots are applied. At least it is not clear even with your latest explanation. Anyways, the current proposal is going toward consecutive slots as it seems to be the direction. |
| Intel | The conclusion from the last meeting is that RAN1 is not defining gaps for beam-switching and will rely on transition time defined by RAN4. Given this conclusion we dont see the need for non-consecutive sub slots. Question: does Alt1 from FFS1 have specification impact ?  Proposal for FFS2 looks ok |
| Fl update #2 | Please use the latest version to comment. Based on first round of inputs, majority direction is Alt.1.  Proposal 2.5: Confirm the working assumption with removing brackets on [consecutive].  Working Assumption  For PUCCH reliability enhancement, support multi-TRP intra-slot repetition (Scheme 3) for all PUCCH formats.   * The same PUCCH resource carrying UCI is repeated for X = 2 ~~[~~consecutive~~]~~ sub-slots within a slot. * Refer the design details related to sub-slot configurations (e.g. other values of X) to Rel-17 eIIoT   Note1: The decision of supporting scheme 3 is only applicable for multi-TRP operation. |
| CATT | For FFS 1, we share same view as QC that we have a conclusion that there is no consensus in RAN1 to introduce gap.  For FFS 2, we are fine to confirm the working assumption and remove the brackets. |
| ZTE | Okay to remove the brackets on [consecutive]. |
| Convida Wireless | For FFS1, prefer Alt 1. |
| Fujitsu | Support FL’s proposal. |
| LG | @Mod: please check our second comment on Section 2.3. |
| Apple | If we want to support consecutive sub-slots only, we can compromise to accept it, but this feature must be optional. Based on the RAN4 LS, without the gap, the performance is problomatic.  Proposal 2.5: Confirm the working assumption with removing brackets on [consecutive] and adding UE capability.  Working Assumption  For PUCCH reliability enhancement, support multi-TRP intra-slot repetition (Scheme 3) for all PUCCH formats.   * The same PUCCH resource carrying UCI is repeated for X = 2 ~~[~~consecutive~~]~~ sub-slots within a slot. * Refer the design details related to sub-slot configurations (e.g. other values of X) to Rel-17 eIIoT   Note1: The decision of supporting scheme 3 is only applicable for multi-TRP operation.  This feature is optional. |
| Samsung | For FFS1, we can support either Alt 2 or Alt3.  We can support to confirm the working assumption (FFS2) in principle but we cannot support to remove brackets on [consecutive] because FFS1 was not agreed. Removing only brackets or entire [consecutive] should be followed after making agreement on FFS1. |
| Lenovo&MotM | For FFS1, we support Alt 2 or Alt 3. And we can support to confirm the working assumption without removing the brackets on [consecutive]. |
| Spreadtrum | Support FL’s proposal. |
| OPPO | The bracket should not be removed.  For FFS1, we prefer Alt.2   * To the proponents of Alt.1: We had an agreement that RAN1 is not defining gaps for beam-switching. It means RAN1 don’t specify there are always gap between sub-slot, e.g., gap for antenna switching. However, from the RAN4 LS, we can see that the transient period may be larger than a CP, it will lead to significant performance loss for two-symbols transmission. Alt.2 is just offer some flexibility that gNB can schedule inconsecutive sub-slots for transmission. Thus, it is still aligned with RAN1 agreement. If only Alt.1 is supported and if gNB think the performance loss due to the transient period is unacceptable, it will never use this feature.   For Alt.3: It is across the slot boundary for 7-symbol subslots. |
| Fl update #3 | @LG, SS, Lenovo, Oppo >> Introducing a switching gap was not agreed in the last time. Even with the new RAN4 reply, they are no longer considering replying to RAN1 such that we can assume any switching gaps for the case of different UE panels. In summary, even without this agreement, the understanding in RAN1 is that there is no switching Gap.  @Apple >> let’s try your version now.  Proposal 2.5: Confirm the working assumption with removing brackets on [consecutive] and adding UE capability.  Working Assumption  For PUCCH reliability enhancement, support multi-TRP intra-slot repetition (Scheme 3) for all PUCCH formats.   * The same PUCCH resource carrying UCI is repeated for X = 2 ~~[~~consecutive~~]~~ sub-slots within a slot. * Refer the design details related to sub-slot configurations (e.g. other values of X) to Rel-17 eIIoT   Note1: The decision of supporting scheme 3 is only applicable for multi-TRP operation.  This feature is optional. |
| InterDigital | We support Apple’s revision with minor a edit.  Proposal 2.5: Confirm the working assumption with removing brackets on [consecutive] and adding UE capability.  Working Assumption  For PUCCH reliability enhancement, support multi-TRP intra-slot repetition (Scheme 3) for all PUCCH formats.   * The same PUCCH resource carrying UCI is repeated for X = 2 ~~[~~consecutive~~]~~ sub-slots within a slot. * Refer the design details related to sub-slot configurations (e.g. other values of X) to Rel-17 eIIoT   Note1: The decision of supporting scheme 3 is only applicable for multi-TRP operation.  This feature is optional for PUCCH format 1, 3 and 4. |

### Question 2.6: Dynamic switching of mapping pattern

**Question 2.6:** Please indicate views on supporting dynamic switching of cyclic mapping and sequence mapping (e.g. based on DCI) as suggested by several companies to provide additional flexibility of the mapping pattern. If RAN1 supports this, what should be the best way to support such a feature.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support dynamic indication to avoid some non-available slots/symbols for UL transmission |
| MediaTek | Do not support. Since multiple PUCCH resources can be configured and one of them can be dynamically indicated by DCI, dynamic switching of beam mapping patterns can already be implicitly supported. |
| QC | We do not support dynamic switching of mapping pattern. First, the design should be consistent with PDSCH schemes in Rel. 16. Second, this is an over-optimization w/o clear use case or benefit while it impacts the DCI signaling. |
| Lenovo&MotM | Don’t support the dynamic switching of mapping pattern. Same view with QC. |
| CMCC | Not support this proposal.  Same opinion with QC. We didn’t see very clear benefit in dynamic switching of mapping pattern. |
| OPPO | Not support. Share the same view as QC |
| Samsung | We don’t see that this feature is essential. As QC’s view, it seems an over-optimization. |
| Vivo | We don’t see the need for the dynamic switching of cyclic mapping and sequence mapping. |
| ZTE | We fail to see any benefits on this enhancement. |
| InterDigital | We are open to further discussing this feature. |
| NEC | Don’t support. |
| TCL | Share the similar view as QC. |
| Spreadtrum | Not support. We share the same view as QC |
| Xiaomi | Support dynamic indication to take the scheduled resource allocation into account. |
| Huawei, HiSilicon | We don’t see the benefits of dynamic switching of beam mapping pattern. |
| Nokia | We don’t support the dynamic switching of beam mapping pattern for PUCCH. However, we are supportive of such dynamic switching for PUSCH (mainly PUSCH repetition Type B). |
| FL Update #1 | No proposal on this. |
| Convida Wireless | Not support. |

### Question 2.7: PUCCH format related aspects

**Question 2.7:** Please indicate views on supporting TRP specific parameters such as ‘initialCyclicShift’ of PUCCH Format 0, ‘initialCyclicShift’ and ‘timeDomainOCC’ of PUCCH Format 1, ‘dataScramblingIdentityPUSCH’ of PUCCH Formats 2, 3 and 4.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Do not support. We failed to see the necessity, but it increases RRC overhead. |
| MediaTek | Do not support. Since sufficient coordination between two TRPs is required to support M-TRP PUCCH schemes, these parameters do not need to be TRP specific. |
| QC | We do not support this. We also did not see the necessity of such enhancements. |
| Lenovo&MotM | Don’t support it. We also didn’t see the necessity. |
| CMCC | Not support this proposal.  We failed to see the benefit of the enhancements. |
| OPPO | Not support as the benefit is not clear. |
| Samsung | We are fine to discuss further. |
| Vivo | Don’t support. |
| ZTE | Support FL’s proposal.  In Rel-15/16, DMRS initialization ID (which denoted as nSCID) is used to guarantee the resulting DMRS generated from pseudo-random sequence to be orthogonal, which is similar to the virtual cell ID in LTE. If the underlying pseudo-random sequence would differ between different co-scheduled Ues, the resulting DMRSs would not be orthogonal. In Rel-17 type 1 CG based MTRP PUSCH scheme, from the same token that the orthogonality between PUSCH DMRSs towards different TRP should be fulfilled, it makes sense to configured the RRC parameter ‘dmrs-SeqInitialization’ for type 1 CG as TRP specific.  @Apple, I fail to see RRC overhead can be the reason to reject this enhancement, which is different with layer 1 signalling, i.e. DCI overhead. |
| InterDigital | It’s not clear what’s the benefit of this enhancements. |
| LG | We failed to see the necessity of this enhancement. |
| NEC | Don’t support. |
| TCL | We are fine to discuss further. |
| Spreadtrum | Don’t support it. We also didn’t see the necessity. |
| Xiaomi | Fine to discuss further |
| Huawei, HiSilicon | We support FL’s proposal. Per TRP parameter configuration is beneficial for PUCCH overhead and flexibility. Essentially, the PUCCH transmission to a TRP is multiplexed with the other Ues within that TRP, therefore, it is critical to have per TRP parameter to guarantee the orthogonality between PUCCH transmissions in that TRP. |
| Nokia | Do not support. |
| FL Update #1 | No proposal on this. |
| Convida Wireless | We are fine to discuss further. |

### Question 2.8: Switching of M-TRP PUCCH schemes

**Question 2.8:** Please indicate the considerations/views on switching of M-TRP PUCCH schemes (Scheme 1 and Scheme 3).

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Different PUCCH resources can be configured with different schemes. The switching can be performed by indicating different PUCCH resources. |
| MediaTek | For switching of PUCCH schemes, we prefer to directly refer to the design of Rel-17 eIIoT, if any. |
| QC | If the intention is switching between PUCCH Schemes 1 and 3, such discussions may not be meaningful now as the sob-slot configurations first need to be decided (by IioT WI). |
| Lenovo&MotM | Same view with MediaTek. |
| CMCC | Same view with MTK and QC. |
| OPPO | Share the same view as MediaTek |
| Samsung | We can wait for the decision from Rel-17 eIIoT. |
| Vivo | We don’t think dynamic switching M-TRP PUCCH schemes is feasible.  In current spec, ubslotLength-ForPUCCH is configured for all PUCCH resources, so that dynamic switching of M-TRP PUCCH schemes may meet unpredictable problems. |
| ZTE | We fail to see the motivation of this enhancement. |
| InterDigital | We share the same view as MediaTek. |
| LG | We share the same view as MediaTek. |
| NEC | Same view with MediaTek and Qualcomm. |
| TCL | Same view with MTK and QC. |
| Spreadtrum | We share the same view as MediaTek. |
| Xiaomi | Fine to discuss further |
| Huawei, HiSilicon | We share the same view as MediaTek. |
| Nokia | Given that Scheme 1 and Scheme 3 are supported, we would need to define how the switching between these schemes is done. The IioT/eURLLC approach where two PUCCH configurations (one slot-based and one sublot-based) are configured is one possibility, i.e. basically PUCCH resource indication would then serve as an implicit indication of PUCCH scheme. If we follow the exact same approach as IioT/eURLLC, it should be clarified whether we would need to have / account for two PHY priorities or not.  Overall, we think the above aspect is worth discussing eventually. |
| FL update #1 | No FL proposal on this. |
| Convida Wireless | OK to refer design to Rel-17 eIIoT, at least for now. |

## 2.3 Additional high priority proposals

In this FL summary, I have not included any FL proposals based on certain other directions discussed before and have not had consensus. If companies wish to bring any additional aspects related to PUCCH during RAN1 #105 -e, please comment below.

|  |  |
| --- | --- |
| Company | Comments |
| vivo | * Support Scheme 2, MTRP intra-slot PUCCH beam hopping, by applying the symbol pattern and DMRS pattern of intra-slot frequency hops for PUCCH formats 1, 3 and 4. * PUCCH group configured for updating spatial relation info can be utilized to link power control parameter sets to a group of PUCCH resources simultaneously. * Mod: Scheme 2 was tried in last two/three meetings. Large number of objections. There is no point wasting effort on that. PUCCH grouping is not very critical to finalize PUCCH enhancements. Only two companies are suggesting enhancements on that. I will create a question on this in second round. |
| ZTE | Group based PUCCH spatial relation updated by MAC CE can be enhanced for Rel-17 MTRP PUCCH scheme.  In RAN1 #104-e meeting, one FFS was raised about whether PUCCH group can be linked to PC parameter sets. Based on that, RAN1 can determine whether PUCCH group should be further enhance for Rel-17 MTRP firstly in this meeting.  Mod: I will create a question on this in the second round. |
| LG | We suggest to discuss beam switching gap issue when only one of multiple panels is activated. Due to panel activation delay, in this case UE cannot support back-to-back PUCCH/PUSCH repetition.  Mod: no consensus even in the online discussion. Similar views expressed under Proposal 2.5 now. it is hard to assume any use of discussing this further. |
| Huawei, HiSilicon | Support of Scheme 2 is important for both reliability and latency.  Mod: Scheme 2 was tried in last two/three meetings. A large number of objections. |
| Futurewei | TA should be discussed. All UL aspects, including separate PC, separate BM, two precoding, etc., have been covered, but no discussion of UL TA, a critical aspect for UL. We have shown in our tdoc that without proper TA, UL transmissions will fail. We also noticed that in RAN2 L1/L2 Scenario 1 (M-TRP like scenarios) discussions, TA issues have been asked by multiple companies. This has to be studied and discussed.  Mod: TA discussion happened in multiple sub-agendas with no agreement. |
| FL Update #1 | Some comments above on vivo, ZTE, LG, HW. FW.  Will start a discussion on PUCCH grouping in the next round. |
| LG | In the last meeting we have no consensus to specify symbol gap but it is applied for the same panel assumption, as highlighted by red below.  With reference to the normative work on NR-feMIMO:  Related to the support of switching gap between UL transmissions towards two TRPs in RAN1 specifications, there is no consensus in RAN1 to specify symbol gap(s) for the following cases  • PUSCH Type A  • PUCCH scheme 1  • PUSCH Type B  • PUCCH scheme 3  The above applies for the case included in the LS from RAN4 in R1-2102297.  In case of different panel case, we still need to discuss this issue considering panel activation delay. Given that panel activation delay is about hundreds of symbols, it may not be able to apply to intra slot PUCCH repetition but should be considered for PUSCH Type A/B and PUCCH scheme 1. |
| Xiaomi | We also prefer to support scheme 2, which is worth discussing again among companies to consider twice. |

# Multi-TRP PUSCH transmission

The remaining open issues and company views are summarized below. The topics discussed by one/two companies or proposals not aligned with earlier RAN1 agreements are not listed to simplify the summary.

## Summary

|  |  |  |
| --- | --- | --- |
| **Issue** | **Summary from Tdocs** | **Moderator comments** |
| Power Control: *TPC command* | Open issue from three meetings. Company views are more or less captured in earlier FL summaries of RAN1 #104-e and #104-bis-e. | FL views that the same solution as PUCCH can be agreed. Check Proposal 2.1. |
| #1: Power control: OLPC | If SRS resource indicator is present   * Two separate OLPC parameter set indication fields (1-bit DCI per TRP) – **FW, vivo,** **Xiaomi, Spreadtrum, QC, Oppo, Intel, Nokia** * The existing OLPC set indication bit field is used – **E///, SS** * A second p0-PUSCH-SetList-r16 is configured **– QC, Oppo, SS** (with a single field)   If SRS resource indicator is not present  Single OLPC field with bit width of 2 or 3 bits can be supported – **vivo**   * According to the service type of transmission, the first bit is used to inform UE which set that P0 is from. The second and third bit is used to select P0 from p0-PUSCH-Set-r16 for PUSCH repetitions towards multiple TRPs respectively – **vivo** | Multiple companies provided inputs on OLPC indication per TRP. At least for the case where SRS resource indicator is present, the majority view is that two separate OLPC parameter set indication fields shall be supported.  The case of SRS resource indicator not present is not discussed in details. Vivo has a proposal on that.  See FL proposal 3.1 |
| #2: Power control: PHR reporting | * Option 1: (2) **QC** (actual PHR), E/// (with dynamic TRP swapping) * Option 2: (8) **Spreadtrum, ZTE, SS**, **Sharp**, **ASUSTeK**, **LG**, **APT, Nokia** * Option 4: (17) **HW, vivo, IDC, Lenovo, OPPO**, **Apple**, **SS**, **MediaTek**, **Xiaomi**, **Convida**, **Sharp**, **LG**, **APT**, **TCL**, **Nokia, Xiaomi, E///** * Option 5: (2) **FW, QC** (virtual PHR)   Other suggestions   * Triggering condition of PHR should be clarified before agreeing on the enhancement on PHR report – **vivo** * Triggering events of PHR shall be defined per TRP – **vivo** * Send LS to RAN2 to ask their opinion on Option 2/Option 4. – **Intel**, **vivo** * Support to configure the higher layer parameters {‘phr-PeriodicTimer’, ‘phr-ProhibitTimer’, ‘phr-Tx-PowerFactorChange’} of PHR trigger events as TRP specific – **ZTE** | RAN1 should down-select one option in this meeting as per the agreement in RAN1 #104-bis, and the majority supports Option 4.  See FL proposal 3.2 |
| #3: Power control: remaining details | Default PC parameters when SRI fields are absent: **vivo, CATT**, **ZTE**, **APT**. **TCL, QC**  Details on default PC   * A first value in {P0-AlphaSet, the PL-RS corresponded to *sri-PUSCH-PowerControlId* = 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 *sri-PUSCH-PowerControlId* = 1 and closed-loop index *l* = 1} for TRP 2 – **ZTE** * A first *sri-PUSCH-PowerControlId* = 0 associated with the first SRS resource set and a second *sri-PUSCH-PowerControlId* = 0 associated with the second SRS resource set are configured – **QC**   + A first (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 (second) *sri-PUSCH-PowerControlId* = 0 associated with the first (second) SRS resource set – **QC** * There are some other flavours mentioned by DCM and CATT, but it seems that variants depend on the assumption of *sri-PUSCH-PowerControl.* | Several companies discuss the issue of SRI field is not present in DCI format 0\_1 and 0\_2, but two power control parameters are configured corresponding to each SRS resource set.  See FL proposal 3.3 |
| #4: PTRS-DMRS association | * Option 1 (4 bits): (5) **Apple**, **Mtek (**DCI 0\_1**),** **Xiaomi**, **QC**, **HW (**configurable**)** * Option 2 (2 bits): (2) **ZTE**, **Qualcomm** * Option 3 (2 bits): (10) **vivo, CATT, OPPO**, **MediaTek (**DCI format 0\_2**),** **E///**, **LG**, **SS**, **HW (**default**), Intel**, **Nokia** | Majority support option 3.  See FL proposal 3.4 |
| #5: A-CSI on M-TRP PUSCH repetition | 1. CSI for the case without a TB:  * Support: **HW**, **vivo**, **OPPO**, **Intel**, **Ericsson**, **TCL**, **Qualcomm**, **Nokia**   Other relevant details   * For multi-TRP PUSCH repetition Type A: multiplexing applied 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. – **QC** * When A-CSI is reported by two PUSCH repetitions, the CPU should be occupied from the last symbol of PDCCH triggering the CSI report until the last symbol of the second PUSCH repetition carrying the report. – **Apple** | A large number of companies support the FFS item on A-CSI on PUSCH without a TB. See FL proposal 3.5.1  For Type A, conditions to apply A-CSI multiplexing is proposed by QC. See FL proposal 3.5.2  On the CPU related proposal from Apple, specs says the following, “*An aperiodic CSI report occupies CPU(s) from the first symbol after the PDCCH triggering the CSI report until the last symbol of the scheduled PUSCH carrying the report*”. From FL perspective, RAN1 can make a conclusion to make things clear for M-TRP operation (no spec impact). See FL proposal 3.5.3 |
| #6: Support dynamic switching | Size of new DCI field   * Two bits field – (20) **FW, HW,** **IDC**, **vivo**, **Lenovo**, **ZTE (**three status), **Fraunhofer**, **Xiaomi**, **DCM**, **LG**, **Ericsson**, **TCL**, **QC**, **Apple**, **CAICT**, **Nokia**, **Oppo, Intel, SS** (if no second SRI field) , CATT(if second TPMI/SRI field is absent) * 1 Bit field: (~~56~~7) **Spreadtrum**, **Covinda**, **ASUSTeK**, **APT**, **CMCC, SS** (if second SRI field exists), CATT(if second TPMI/SRI field exists)   SRI/TPMI field applied for S-TRP indication   * First SRI (for NCB)/TPMI (for CB) field is used when the DCI indicates all repetitions are associated with one SRS resource set – **QC, E///** * Corresponding SRI (for NCB)/TPMI (for CB) field is used when the DCI indicates all repetitions are associated with one SRS resource set – **Oppo, DCM**   Other details   * Associating SRS resource sets and sets of repetitions – **QC, SS (?), Fraunhofer, DCM** * Discuss also possibilities of reusing one or more entries in SRI and/or TPMI (e.g. when 2 bit filed is not configured) – NEC, **SS**, **CATT, ZTE** * MAC CE can be introduced to activate the codepoints for the introduced new field to further reduce the overhead – **vivo** | Majority support 2-bit field for dynamic switching. Few companies provided details on mapping, and indicating all four combinations (TRP1, TRP2, TRP1-TRP2, TRP2-TRP1) is the way to go.  Two companies discuss which SRI/TPMI field to associate when a single TRP is indicated. FL thinks that the first SRI/TPMI can be used without any big issue.  Another discussion was on how the SRS resource sets are mapped to combinations of DCI indication (or TRPs). As proposed by few companies, a simple association from SRS resource set ID can be used.  See FL proposal 3.6-1 and 3.6-2 |
| #7: NCB based PUSCH: 2nd SRI field | Confirm the WA on the second SRI field: **HW**, **IDC**, **Lenovo**, **OPPO**, **Xiaomi**, **Sharp**, **Ericsson**, **APT**, **Nokia**  Set of SRS port number of SRS resource(s) in two SRS resource sets are expected to be same. – **vivo** | Confirming working assumption seems possible.  See FL proposal 3.7 |
| #8: CB based PUSCH: 2nd TPMI design | Support PUSCH repetitions transmitting towards multiple TRPs sharing the same TPMI – **vivo, QC**   * The presence of the second TPMI field can be separately configured for DCI format 0\_1 and DCI format 0\_2**. – QC** | This was discussed before, and companies had different opinions. See question 3.8 |
| #9: M-TRP CG PUSCH: RV mapping | RV sequence   * The first RV for the first PUSCH repetition and a RV offset for the starting RV for the second TRP are configured – **CATT, QC, Intel, Oppo, Nokia** * Support two RV sequences **– Xiaomi**   Starting RV for transmission   * RV sequence is always expected to be mapped starting with 0 onto the first transmission occasion targeting each TRP – **Xiaomi** * with RV pattern 0231, support initial transmission at the first transmission occasion of TRP 1 or at the first transmission occasion of TRP 2. – **LG** * If startingFromRV0 is set to ‘off’, the initial transmission of a TB may start at the first transmission occasions associated with different UL beams. – **TCL** * If startingFromRV0 is set to ‘on’, for each of the two sets of the transmission occasions associated with different UL beams, the initial transmission of a TB may start at any of transmission occasions with RV=0 – **TCL**   Other  a new field can be introduced to indicate the second RV sequence – TCL | Several companies indicated that RV sequence should be configured to be the same for both TRPs. Also, similar to DG-PUSCH an offset may be configured for the second TRP.  On the starting RV, TCL and Xiaomi referred to the different modes supported in Rel-16 by *startingFromRV0,* which is controlling CG PUSCH initial transmission start from any transmission with RV0 or always starting with the initial transmission.  See FL proposal 3.9. |
| #10: M-TRP CG PUSCH repetition: PTRS-DMRS association | * Clarification of UL PT-RS port(s) and DM-RS port(s) for CG type 1 towards multiple TRPs is required – **vivo, Nokia** * For type 1 CG, support the same association rule between PT-RS and DM-RS as in Rel-15/16 – **Oppo, CATT, Nokia** * Support PT-RS to DMRS port association cycling. The associated DMRS port index for a PT-RS port should be selected based on the repetition index – **Apple** * For Type 1 CG, each PTRS port is associated with the 1st scheduled DMRS port sharing the PTRS port.: **CATT** | Views are diverging, and very few inputs. Based on companies’ inputs, there seems nothing needed to enhance on PT-RS DMRS association where the association rule from Rel-15/16 can also apply for m-TRP operation.  See FL proposal 3.10 |
| #11: M-TRP CG PUSCH: other details | CG Type 1   * For type 1 CG, support to introduce the second field of ‘dmrs-SeqInitialization’ in ‘rrc-ConfiguredUplinkGrant’. – **ZTE, Intel** * if the higher layer parameter of rrc-ConfiguredUplinkGrant is not included in ConfiguredGrantConfig, the PL-RS resource index for two TRPs should be determined.- **TCL**   CG type 2   * Two default beams can be applied for CG type 2 when it is activated by DCI format 0\_0. **– vivo** * For type 2 CG based multi-TRP PUSCH repetition: 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. – **QC**   Other   * Further enhance power control of CG retransmission: At least PL-RS of the scheduled retransmission shall be indicated by the scheduling DCI instead of reusing the one configured for CG. – **vivo** | Different views, but mainly one or two company proposals.  On CG Type 1, two companies propose to use different DMRS sequence initialization. But this is not used for DG-PUSCH in multi-TRP, and does not make sense only to introduce for CG PUSCH. RAN1 can come back to this if DG PUSCH uses such an approach.  On CG Type 2, QC proposal on how the DCI field applicable for CG PUSCH seems relevant.  See FL proposal 3.11. |
| #12: PUSCH Frequency hopping | * For inter-repetition frequency hopping with PUSCH repetition Type A or Type B, frequency hopping is performed among the repetitions with the same beam when cyclical mapping pattern is configured. – **QC**, **Fujitsu, LG, Lenovo, CATT, E///** * Support beam mapping per frequency hop when inter-slot frequency hopping is configured – **vivo** * The two transmission occasions are associated with two TRPs respectively, regardless of the configured beam mapping pattern **– CATT** | The majority supports the per TRP inter-repetition FH. See FL proposal 3.12. |
| #13: Collision between PUCCH(s) and PUSCH(s) | * When mTRP PUSCH collides with PUCCH, support that UCI can be transmitted in the first actual PUSCH repetition that meets Z and Z’ requirement (if applicable) corresponding to each beam. – **Apple** * When PUCCH without repetition carrying HARQ-ACK and/or CSI overlaps with multi-TRP PUSCH transmission, the UCI of the PUCCH is multiplexed on two PUSCH repetitions with different beams.- **HW** * Discuss different cases of overlapping PUCCHs/PUSCHs for multi-TRP operation to be further discussed – **APT** | Not the most essential feature to finalize the design details. We can come back to this later. |

## 3.2 Feature lead Proposals

### Proposal 3.1: OLPC set indication

**[Draft for offline] Proposal 3.1:** For indicating per-TRP OLPC set in DCI format 0\_1/0\_2,

* If two SRI fields present in the DCI,
  + Support a second field (1 bit) for OLPC set indication and a second p0-PUSCH-SetList-r16.
  + The first and second OLPC field are associated with the repetitions corresponding to first SRI and second SRI field, respectively.
  + For first and second OLPC fields,
    - if value of the field equals to ‘0’, the UE determine value of P0 from a first P0-PUSCH-AlphaSet 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 the lowest p0-PUSCH-SetID value corresponding to each TRP.
* If the SRI field is not present in the DCI,
  + Support a single extended field (2 bit or 3 bits as determined by higher layer parameter olpc-ParameterSetDCI-0-1/0-2) for OLPC set indication and a second p0-PUSCH-SetList-r16.
  + FFS: details on interpretations

Please comment on preferred changes to the proposal. Please provide your views on FFS.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | We do not think the proposal is needed.  Current 1-bit indicator when 2 SRI fields present can still be used to indicate OLPC for 2 beams. gNB can apply the same principle to configure the 2 OLPC sets for each beam, so that it can be switched at the same time. So no additional DCI overhead is needed.  When SRI is not present in DCI. Current proposal looks problematic, as it introduces additional overhead but the interpretation is FFS. We cannot support additional DCI overhead without clear interpretation.  Mod: your view is considered as Alt.2 in the updated proposal. |
| MediaTek | Do not support. Per-TRP OLPC set indication by DCI is unnecessary.  Mod: RAN1 agreed to support this last time. So we do not discuss support or not at this stage. Please suggest the indication method. |
| QC | Support the proposal for the case of SRI fields present. When SRI fields are not present can be decided later (also depends on the outcome of Proposal 3.3).  From our perspective, proper enhancement cannot be done if the second OLPC set indication field (1bit) is not added in the DCI as gNB cannot separately control power boost or no power boost per TRP in that case. A half-way enhancement (e.g. by only adding a second RRC w/o adding the corresponding DCI field) is not a good way in our view especially given the fact that the two TRPs see different interference (from other eMBB Ues). |
| Lenovo&MotM | Support. |
| CMCC | Not support.  We prefer the following revised version:  [Draft for offline] Proposal 3.1: For indicating per-TRP OLPC set in DCI format 0\_1/0\_2,   * If two SRI fields present in the DCI,   + Support a second field (1 bit) for OLPC set indication and a second p0-PUSCH-SetList-r16.   + The first and second OLPC field are associated with the repetitions corresponding to first SRI and second SRI field, respectively.   + For first and second OLPC fields,     - if value of the field equals to ‘0’, the UE determine value of P0 from a first P0-PUSCH-AlphaSet 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 corresponding SRI field value. * If the SRI field is not present in the DCI,   + Support a single extended field (2 bit or 3 bits as determined by higher layer parameter olpc-ParameterSetDCI-0-1/0-2) for OLPC set indication and a second p0-PUSCH-SetList-r16.   + FFS: details on interpretations   Mod: Should be ok with vivo suggestion ? |
| OPPO | For first sub-bullet, we do not think a second field(1bit) for OLPC set indication is required since we don’t see the use case where one TRP needs the OLPC parameter and the other needs the R15 parameter  For second sub-bullet, we want to see more details.  Mod: I will count you in the second alternative, as I was reading you supported alt.1.   * Alt. 2: The existing OLPC set indication bit field is used – **E///, SS, apple, Oppo, HW, LG**   Second FFS needs inputs as no one provided details other than vivo. We can discuss it later, |
| Samsung | We don’t support two OLPC fields based method. Although two OLPC fields based method can support flexibility to indicate whether power boost per-TRP is applied or not, we don’t need to increase DCI overhead for that kinds of optimization. If power boost is conducted for the TRP that doesn’t suffer from interference, it is not useless but can increase the reliability for URLLC traffic.  And also, the another purpose of the OLPC field can be to indicate whether p0 value is from eMBB parameter sets or URLLC parameter sets if UE can support both eMBB and URLLC services. However, it is not natural that one p0 value for TRP1 is selected from the URLLC parameter sets and the other p0 value for TRP2 is selected from the eMBB parameter sets.  Hence, a single field is enough to indicate whether the selected p0 values for both TRPs are from eMBB or URLLC paramtere sets. To elaborate a single OLPC field based method, the OLPC field can be associated with two P0-PUSCH-SetLists and two SRI fields. If the OLPC field is set to ‘1’, two p0 values for both TRPs are selected from p0-PUSCH-Set corresponding to each SRI field in each P0-PUSCH-SetList.  Mod: your view is considered as Alt.2 in the updated proposal. |
| Vivo | Support the proposal with the following modification, as the original wording is for the case when SRI field is absent:  [Draft for offline] Proposal 3.1: For indicating per-TRP OLPC set in DCI format 0\_1/0\_2,   * If two SRI fields present in the DCI,   + Support a second field (1 bit) for OLPC set indication and a second p0-PUSCH-SetList-r16.   + The first and second OLPC field are associated with the repetitions corresponding to first SRI and second SRI field, respectively.   + For first and second OLPC fields,     - if value of the field equals to ‘0’, the UE determine value of P0 from ~~a first P0-PUSCH-AlphaSet~~ *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 ~~with the lowest p0-PUSCH-SetID value~~ corresponding to each TRP. * If the SRI field is not present in the DCI,   + Support a single extended field (2 bit or 3 bits as determined by higher layer parameter olpc-ParameterSetDCI-0-1/0-2) for OLPC set indication and a second p0-PUSCH-SetList-r16.   + FFS: details on interpretations   Mod: your updated looks ok. will consider this. |
| ZTE | Only support the case of SRI fields are present in DCI. |
| LG | We support separate configuration for P0-PUSCH-AlphaSet and P0-PUSCH-Set corresponding to each TRP but do not support DCI enhancement for the same reason commented by Apple and Samsung.  Mod: I will count you in the second alternative.   * Alt. 2: The existing OLPC set indication bit field is used – **E///, SS, apple, Oppo, HW, LG** |
| TCL | For first sub-bullet, we support two OLPC fields based method and are fine with vivo’s revision.  For second sub-bullet, when SRI fields are not present, we are fine to study this case later as it depend on whether the two OLPC fields based method is supported or not.  Mod: vivo suggestion is considered in the update. |
| Xiaomi | Support FL’s proposal for the case when SRI fields are present, and discuss the solution later for the case whlen SRI field is not present. |
| Huawei, HiSilicon | For open loop power control, we do not see the necessity to add new bits.  Mod: I will count you in the second alternative.   * Alt. 2: The existing OLPC set indication bit field is used – **E///, SS, apple, Oppo, HW, LG** |
| Nokia | Further discussion on options are needed. |
| Futurewei | We support the most straightforward extension from the existing specs. In the existing specs, if the value is 0, then the UE obtains P0 from P0-alpha set based on SRI, but if the value is 1, then the UE “determines a value of P0\_UE\_PUSCH,b,f,c(j) from a first value in *P0-PUSCHSet* with a *p0-PUSCH-SetId* value mapped to the SRI field value”. Therefore, with the SRI fields, only the version by vivo is consistent with the current spec. When SRI fields are absent, it is a bit more complicated to indicate for 2 TRPs, so we suggest FFS.  So we support the first part by vivo, but suggest to FFS for the case when SRI field is not present.  Mod: vivo suggestion is considered in the update. |
| Fujitsu | We are fine with the FL’s proposal for the case when SRI fields present in the DCI. |
| NTT Docomo | Support FL proposal for the case when SRI fields are present. |
| Ericsson | Do not support FL’s proposal.  We don’t see the need for indicating eMBB P0 for one TRP/beam and URLLC P0 for the other TRP/beam. We are fine to have different lists of P0-PUSCH for different TRPs/beams though. Also, we don’t see the need for introducing two OLPC fields. Using a single field should be sufficient.  Mod: I will count you in the second alternative. |
| Intel | the case of SRI field not present is very unclear now. Suggest to limit the proposal only to the case of SRI field present case.  Mod: inputs on that only provided by vivo. |
| FL Update #1 | Based on inputs several companies, company positions at least for the case of SRI field is present case is as below,   * Alt.1: Two separate OLPC parameter set indication fields (1-bit DCI per TRP) – **FW, vivo,** **Xiaomi, Spreadtrum, QC, Nokia, Lenovo, CMCC, TCL, DCM, Intel, Fujitsu, ZTE** * Alt. 2: The existing OLPC set indication bit field is used – **E///, SS, apple, Oppo, HW, LG**   **Proposal 3.1:** For indicating per-TRP OLPC set in DCI format 0\_1/0\_2,   * **FFS1:** If two SRI fields present in the DCI, select one of following two alternatives, * Alt1:   + Support a second field (1 bit) for OLPC set indication and a second p0-PUSCH-SetList-r16.   + The first and second OLPC field are associated with the repetitions corresponding to first SRI and second SRI field, respectively.   + For first and second OLPC fields,     - if value of the field equals to ‘0’, the UE determine value of P0 from ~~a first P0-PUSCH-AlphaSet~~ *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 ~~with the lowest p0-PUSCH-SetID value~~ corresponding to each TRP. * Alt2:   + 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. * **FFS2:** If the SRI field is not present in the DCI,   + ~~Support a single extended field (2 bit or 3 bits as determined by higher layer parameter olpc-ParameterSetDCI-0-1/0-2) for OLPC set indication and a second p0-PUSCH-SetList-r16.~~     - ~~FFS: details on interpretations~~   Please indicate your views on FFS1 and FFS2, so that we can at least capture several alternatives on FFS2 as well.  For FFS1, Alt.1 is the majority view. |
| Convida Wireless | We also prefer Alt 2. |
| ZTE2 | For FFS1, our preference is Alt 1. |
| Fujitsu | For FFS1, Alt.1 is preferred. |
| Apple | Our understanding is that Alt2 is already in spec. We do not need this proposal. |
| Samsung | We support Alt2.  As mentioned before, to obtain the reliability requirement on URLLC, two p0 values can be selected from p0-PUSCH-SetLists (p0 parameter set for URLLC). |
| Lenovo&MotM | We prefer Alt 1. |
| MediaTek | For FFS1, we support Alt 2. |
| QC2 | The updated FL proposal is clearer, and we support Alt1 for FFS1. We think Alt2 cannot address the original motivation of the agreement in the previous meeting. If only one set of repetitions require power boost, power boosting all repetitions will increase inter-cell interference for UL and is harmful to the system capacity. In typical use case, the eMBB UE creates interference at only one of the TRPs, and hence, separate control for power boost is needed. |
| OPPO | For FF1, we prefer Alt.2 |
| Xiaomi | For FFS1, we support Alt.1. |
| vivo4 | For FFS1, we support Alt1.  For FFS2, we are OK to FFS. We think it is a valid case to specify.  In Rel-16, when SRI field is not present in DCI, OLPC field can be configured with one bit or two bits for DCI format 0\_1 and DCI format 0\_2 separately. The use case of 2 bits is that UE can be indicated with three levels of P0 values respectively for three kinds of scheduling conditions: P0 for eMBB, higher P0 for URLLC, highest P0 for URLLC power boosting when multiplexing with other URLLC UEs.  In MTRP PUSCH TDMed repetition, If OLPC field remains as Rel-16, it will apply to the repetitions for both TRPs. For the case of multiplexing with other URLLC UEs occur only on one of the TRPs, if the highest P0 for URLLC with power boosting is indicated for both TRPs to acquire better performance, it will cause power waste and inter-UE interference for the TRP without multiplexing URLLC UEs; if the higher P0 is selected for both TRPs, the worse performance of repetitions multiplexed with URLLC UE will be seen. So, it is better to indicate separate P0 values for two TRPs to obtain the tradeoff between power efficiency and the performance of repetitions towards both TRPs. |

### Proposal 3.2: PHR reporting

**[Draft for offline] Proposal 3.2:** For PHR reporting related to M-TRP PUSCH repetition, option 4 is supported,

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

Please comment on preferred changes to the proposal. Select your preference for FFS.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Suuport |
| MediaTek | Support |
| QC | Do not support. Option 4 has issues wrt causality of PHR report. In existing spec, PHR-MAC-CE does not include “actual PHR” for future slots. For example, for the case of UL CA, only PUSCHs overlapping in the slot of the PUSCH that carries the MAC-CE are considered.    This is because if PHR for a PUSCH in the future is reported, the scheduling condition for other CCs are not know, and hence, PHR value does not reflect the power allocation on those CCs (which impact the PHR of the target CC).  In addition, Option 4 results in many RAN2 changes including MAC-CE change, triggering condition, introduction of additional timers (if the intention is per-TRP PHR). We do not think there is enough TU in RAN2 for such enhancements.  In our view, Option 1 is the simplest solution, keeps the actual PHR reporting causal (as in current spec), and allows for alternating between the two TRPs for UL CA as well as in the absence of UL CA when dynamic switching of TRP order is allowed.  [Mod] : On the first issue, it is not fully clear why option 4 can not define such a way that it handles the concerns you raised. Also, it does not have to obey always to the current specification and this is a new enhancement. The majority seems to view that per TRP PHR reporting should be supported and build the framework around that. FFS2 appears to be asking the question you raised.  On Ran2 impact, compared to other sub-items, we do not have big changes or work towards RAN2. It should not be a restriction to avoid an enhancement.  Option 1 is not supported by the majority, as you may have seen from contributions. |
| Lenovo&MotM | Support. |
| CMCC | Support. |
| OPPO | Support |
| Samsung | Support FL’s proposal. |
| Vivo | The trigger conditions should be clarified first before make a resolution on PHR reporting for PUSCH repetitions towards multiple TRPs. |
| ZTE | Although both option 2 and option 4 can fulfill per TRP PHR reporting, option 2 should be supported with the following analyses.   * For option 2, it can guarantee a great flexibility when considering TRP specific PHR event triggering. Besides, noted that RAN2 time budget is very limited for Rel-17, it can be simple to use one reserved field in Single/Multiple Entry PHR MAC CE to fulfill option 2. * For option 4, it will cause too much spec changes since a new MAC CE design has to be introduced. Besides, it may be mandatory to report two PHR values corresponding to two TRPs every time, no matter whether it is really necessary or not. The signaling overhead will be huge.   In the light of the above elaboration, we think option 2 should be supported to fulfill TRP specific PHR reporting without much specification effort. We suggest to update this proposal as below:  [Draft for offline] Proposal 3.2: For PHR reporting related to M-TRP PUSCH repetition, option 2 is supported,   * Option 2: Calculate two PHRs, each associated with a first PUSCH occasion to each TRP, but report one of them   + FFS: How to select the PHR for reporting. * FFS1: Required changes to triggering conditions including the required higher layer parameters (e.g.,’phr-PeriodicTimer’, ‘phr-ProhibitTimer’, ‘phr-Tx-PowerFactorChange’ as TRP specific). * FFS2: Support extensions to both single-cell PHR MAC CE and multi-cell PHR MAC CE * FFS3: Report P-MPR and MPE per TRP within the same MAC-CE extension. * FFS4: Send LS to RAN2 as the design details are mainly relevant to RAN2.   Mod: Option 4 is supported by a clear majority. Let’s try to discuss FFS points and identify issues/solutions on those. |
| InterDigital | We support FL’s proposal. |
| LG | We support FL’s proposal. |
| NEC | Support the proposal. |
| TCL | We support FL’s proposal. |
| Spreadtrum | Not support the proposal, we share the similar views as ZTE.  For Option4, reporting two PHRs perhaps will introduce new MAC CE, and bring in additional spec work load. It is not preferable, especially considering limited FeMIMO Tus in RAN2. Thus, we prefer option2.  Mod: same comment as ZTE. |
| Xiaomi | Support the FL’s proposal |
| Huawei, HiSilicon | Support FL’s proposal. The FFS1/2/3 seem to be within the work scope of RAN2/RAN4. |
| Nokia | Support the FL’s proposal.  We can also be OK with Option 2 as it doesn’t increase the overhead. |
| Futurewei | We suggest to clarify some technical issues first, e.g.:   * Is there any soft combining requirement for the PUSCH repetitions across the TRPs? If yes, then with Option 4, 2 PHR reports have to be sent for all repetitions and this imposes some restriction for RAN2 design. * When sending the first PUSCH, are the PHRs computed based on the first and second (future) PUSCHs? Is the second PHR real (actual) or virtual? * Option 5 and Option 1 are essentially the same. Suggest to clarify.   Mod: Some comments on your questions based on my reading.   * It is not clear why soft combining is related to PHR reporting. Please clarify. * Second PHR can be virtual or actual, according to my reading. But that discussion is indeed needed if we support a report of two values. * They are not the same. Also, it does not matter anymore as companies do not support those. Please check QC contribution as they see it differently. |
| Fujitsu | Support FL’s proposal. |
| NTT Docomo | Support FL’s proposal. |
| Ericsson | Support FL’s proposal. |
| Intel | Support FL proposal |
| FL update #1 | Majority support the proposal. However, QC, ZTE, vivo, Spreadtrum seems to have concerns. I have some comments for them. Others>> please further explain details.  FL proposal is not changed. |
| ZTE2 | @FL, given that TDMed repetition scheme is the baseline of Rel-17 MTRP PUSCH, reporting one PHR for one TRP which associated with the first PUSCH occasion is enough and reasonable. Besides, noted that RAN2’s time budgets for Rel-17 is very limited, it is reasonable to adopt a simple approach which minimize spec effort for RAN2, rather than the one which need a new design of MAC CE. Based on the above technical reasons, we believe option 2 should be supported instead of option 4.  Regarding FFS1, it is natural to configure PHR trigger events as TRP specific for more flexibility,which include 'phr-PeriodicTimer' for periodically triggering, 'phr-ProhibitTimer' for the prohibit timer expires, and 'phr-Tx-PowerFactorChange' for change in PL-RS power. How to configure such parameters as TRP specific can be further discussed in RAN1. One straightforward way is to add 'phr-PeriodicTimer2', 'phr-ProhibitTimer2' and 'phr-Tx-PowerFactorChange2' in 'PHR-Config'. After that, associated each PHR trigger events related parameter set with SRS resource set, respectively.  Regarding FFS2 and FFS3, it can be simple and easy to redesign the current single-cell and multi-cell PHR MAC CE for option 2, which is using one reserved field in the current Single/Multiple Entry PHR MAC CE to indicate the reported PHR towards which TRP. Noted that P-MPR and MPE report per TRP is not required, the redesign of MAC CE for option 2 will not impact the legacy P-MPR and MPE report approach.  Regarding FFS4, it is natural to let RAN2 determine the relevant design for this enhancement. |
| Convida Wireless | Support FL’s proposal |
| Samsung | Support FL’s proposal. Our first preference is Option 4. Option2 can be also considerable but, for the flexibility Option4 is superior to Option2. For example, gNB can decide whether to support mTRP transmission or sTRP transmission based on the two reported power headrooms of both TRPs. If the remaining power is too small for TRP1 and there is huge remaining power for TRP2, gNB can decide to schedule sTRP PUSCH repetition with TRP2. Two reported power headroom can be helpful to schedule PUSCH transmission or manage transmission power efficiently.  On RAN2’s impact, we have same view with FL. |
| QC2 | We did not see response to our concerns from the supporting companies other than FL’s response. So, I assume companies have noticed the issues raised by us.  @FL: This is a major departure from Rel. 15/16 assumption. With Option 4 (or Option 2), UE’s complexity is increased in a non-trivial way. Basically, this results in a third kind of PHR, which is something between actual and virtual PHR. Then, UE needs to calculate power multiple times: One time for the PHR report for some PUSCH repetition in the future w/o the knowledge of which one of the other CCs have PUSCH, and another time for the actual power calculation for transmission of that repetition. This complexity is not acceptable given that the report PHR is anyway useless most of the time (it does not reflect the actual power).  On the other hand, Option 1 with dynamic switching of TRP order can address the issue, does not increase UE complexity, does not have RAN2 impact, corresponds to the actual power, and does not introduce a third kind of PHR report (semi-actual/semi-virtual PHR). |
| Spreadtrum | Our first preference is Option2. The UE always report the smaller PHR for simplicity. Firstly, it will not introduce much spec efforts. Secondly, reporting one PHR from one TRP is enough. The network can adjust the power based on the smaller PHR for both links, which will not exceed the power headroom of both links.  If majority companies support this proposal, we can accept Option4 for sake of progress. |
| APT/FGI | We support FL’s proposal. Considering that the channel conditions between a UE and different TRPs are different, calculating 2 PHRs is reasonable. So, we can also support option 2 except option 4. |
| InterDigital | Support Option4, and similar view as Samsung that reporting two PHR reports is beneficial for mTRP operation. As for RAN2, we don’t believe that there would be much work. |

### Proposal 3.3: Default PC parameters

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

* 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 signalling link *sri-PUSCH-PowerControl with* two SRS resource sets is up to RAN2.

Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support the main-bullet only.  In our view, the default values should be selected from the first value from corresponding list configured by RRC, e.g. the first PL-RS configured in corresponding PL-RS list, which is like current pproach for default power control parameters. It is not good to bind default values with SRI, since there may be no SRI when unified TCI is enabled. |
| MediaTek | Support |
| QC | Support the proposal.  We should avoid piecemeal rules in this case (one set of default rules for P0 and alpha, another set of rules for PL-RS, yet a different set of rules for closed loop index). Otherwise, the spec will become unreadable. |
| Lenovo&MotM | Support. |
| CMCC | Support. |
| OPPO | Support |
| Samsung | We can support FL’s proposal. |
| Vivo | We share similar views as Apple. Default PC parameters shall be defined with minimum spec impact. |
| ZTE | We are NOT supportive of this proposal.  In the current TS38.213, it can be seen that default PC parameters (which include the first *P0-PUSCH-AlphaSet* in *p0-AlphaSets*, *PUSCH-PathlossReferenceRS-Id* = 0, closed loop index *l* = 0) are configured when a DCI format does not include an SRI field, or when an *SRI-PUSCH-PowerControl* is not provided to the UE. For the sake of forward compatibility, it is natural to take the same rule for MTRP PUSCH scheme in Rel-17. That is to use the first and second values of {*P0-PUSCH-AlphaSet* in *p0-AlphaSets, PUSCH-PathlossReferenceRS-Id*, closed loop index *l*} as defined default PC parameters per TRP.  @QC, regarding the value of P0/alpha, PL-RS id, and closed loop index, such PC related parameters are indeed defined separated in the current specs. If default PC parameters are associated with *sri-PUSCH-PowerControl*, the rules between Rel-15/16 and Rel-17 MTRP are different, that will lead to unreadable for specs in fact.  We suggest to adopt the following updated proposal:  [Draft for offline] Proposal 3.3: For single-DCI based M-TRP PUSCH repetition schemes, when one SRS resource per SRS resource set is configured (i.e., when two SRI fields are absent in DCI formats 0\_1 / 0\_2), default P0, alpha, PL-RS, and closed loop index is defined per TRP.   * The first and second default values of {*P0-PUSCH-AlphaSet* in *p0-AlphaSets, PUSCH-PathlossReferenceRS-Id*, closed loop index *l*} are associated with the first and second SRS resource set, respectively. * Note: How to design the detailed signalling is up to RAN2. |
| InterDigital | We support FL’s proposal. |
| LG | We support main bullet only. As commented by Apple, VIVO and ZTE, we can extend legacy default PC parameter to support two PC parameters. We are also fine with ZTE’s revision. |
| NEC | Support the proposal. |
| TCL | Do not support.  Similar to the rule of default PC parameters in the current TS38.213, if two *sri-PUSCH-MappingToAddModList* are configured, the first default values of {*P0-PUSCH-AlphaSet* in *p0-AlphaSets*, *PUSCH-PathlossReferenceRS-Id*, closed loop index *l*} in two *sri-PUSCH-MappingToAddModList* are associated with the first and second SRS resource set, respectively. |
| Spreadtrum | Support the main bullet only. We share the similar views as LG, ZTE. |
| Xiaomi | Support the FL’s proposal |
| Fraunhofer IIS/HHI | Support FL proposal |
| Huawei, HiSilicon | Support FL’s proposal. |
| Nokia | Support. |
| Futurewei | Support |
| Fujitsu | Support FL’s proposal. |
| NTT Docomo | Support the main bullet. Share similar view with Apple/ZTE/LG/vivo |
| Ericsson | Support the main bullet only, or ZTE’s version. We share similar views with Apple/ZTE/LG/vivo/NTT Docomo. |
| Intel | We support in principle but seems pre-mature at this time: what is the triggering condition for a UE to interpret 2 default PC parameters vs 1 default PC parameter. We belive this depends on how RAN2 decides to link SRI fields to two power control parameters. If, for e.g, RAN2 decides to have *sri-PUSCH-MappingToAddModList* and *sri-PUSCH-MappingToAddModList-2* configuration, then association to SRS resource sets may not be needed. The first entry in these 2 lists can be used as default parameters. |
| CATT | Support main bullet. For the details, we have similar view as ZTE that default power control parameters should not be associated with *SRI-PUSCH-PowerControl*.  The following update is preferred:  [Draft for offline] Proposal 3.3: For single-DCI based M-TRP PUSCH repetition schemes, when one SRS resource per SRS resource set is configured (i.e., when two SRI fields are absent in DCI formats 0\_1 / 0\_2), default P0, alpha, PL-RS, and closed loop index is defined per TRP. One of the following alternatives is supported:   * Alt 1: The first and second default values of {*P0-PUSCH-AlphaSet* in *p0-AlphaSets, PUSCH-PathlossReferenceRS-Id*, closed loop index *l*} are associated with the first and second SRS resource set, respectively if same lists of *p0-AlphaSets, PUSCH-PathlossReferenceRS-Id*, and closed loop index *l* are shared by the two SRS resource sets. * Alt 2: The first value of *P0-PUSCH-AlphaSet* in *p0-AlphaSets, PUSCH-PathlossReferenceRS-Id* =0, the first value of closed loop indexthat associated with the first and second SRS resource set, respectively, if different lists of *p0-AlphaSets, PUSCH-PathlossReferenceRS-Id*, and closed loop index *l* for the two SRS resource sets respectively are supported. * Note: How to design the detailed signalling is up to RAN2. |
| FL Update #1 | In summary, there is good support on the main bullet but not on the sub-bullets as companies suggest another variant.  @ ZTE, Apple, vivo, CATT >> it seems you all suggest capturing a scenario where *SRI-PUSCH-PowerControl* associated to SRS resource sets are not provided to the UE. However, it is not fully clear why would gNB enable multiple TRP repetition without providing SRI-PUSCH-PowerControl. Could you first clarify the use case rather than discussing alternatives to resue extension from rel-15.  Also, please check what you suggested captured correctly or not in Alt.2. We could discuss further when more details are provided.  **Proposal 3.3:** For single-DCI based M-TRP PUSCH repetition schemes, when one SRS resource per SRS resource set is configured (i.e., when two SRI fields are absent in DCI formats 0\_1 / 0\_2), default P0, alpha, PL-RS, and closed loop index is defined per TRP.  [Select one from the following,]   * Alt.1 * The first P0/alpha, PL-RS, and closed loop index are determined by *sri-PUSCH-PathlossReferenceRS-Id*, *sri-P0-PUSCH-AlphaSetId*, and *sri-PUSCH-ClosedLoopIndex* mapped to the first *sri-PUSCH-PowerControl* associated with the first SRS resource set. * The second P0/alpha, PL-RS, and closed loop index are determined by *sri-PUSCH-PathlossReferenceRS-Id*, *sri-P0-PUSCH-AlphaSetId*, and *sri-PUSCH-ClosedLoopIndex* mapped to the first *sri-PUSCH-PowerControl* associated with the second SRS resource set. * Note: How to design the signalling 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 sri-PUSCH-PowerControlId = 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 sri-PUSCH-PowerControlId = 1 and closed-loop index l = 1} can be used for TRP2.] |
| ZTE | @FL, in FR2, when the two SRI field are absent in DCI, it means gNB will configure only one SRS resource in the two SRS resource sets for MTRP PUSCH scheme, respectively. Correspondingly, I fail to see the necessity of providing SRI-PUSCH-PowerControl. In Rel-15/16, SRI-PUSCH-PowerControl is used to associate power control parameters (which comprise P0/Alpha, PL-RS Id, closed loop index) with one SRS resource which selected by SRI field. When one SRS resource configured in SRS resource set, there is no SRI field in DCI and no SRI-PUSCH-PowerControlId in RRC, then default PC parameters {P0/Alpha, PL-RS Id, closed loop index} are defined without SRI-PUSCH-PowerControl according to the current TS38.213 as below. Therefore, it makes sense to use first and second default values of such PC parameters, and this approach can fall back to Rel-15/16 mechanism as well as minimize the spec effort. What’s the problem of gNB enabling multiple TRP repetition without providing SRI-PUSCH-PowerControl?   * ***sri-PUSCH-PowerControlId* in TS38.331**   The ID of this *SRI-PUSCH-PowerControl* configuration. It is used as the codepoint (payload) in the SRI DCI field.   * **Default P0/Alpha in TS 38.213**   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.*   * **Default PL-RS Id in TS 38.213**   If the PUSCH transmission is scheduled by DCI format 0\_1 or DCI format 0\_2 that does not include an SRI field, ..., the UE determines a RS resource index with a respective *PUSCH-PathlossReferenceRS-Id* value being equal to zero where the RS resource is either on serving cell or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking.*   * **Default closed loop index in TS 38.213**   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, |
| Fujitsu | Support FL’s proposal. |
| LG | We have the same understanding with ZTE. We suggest to revise Alt 2 independent from sri-PUSCH-PowerControl as follows:   * Alt.2 * The first set of values {the first value in P0-AlphaSet, the PL-RS corresponded to ~~sri-PUSCH-PowerControlId~~*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 ~~sri-PUSCH-PowerControlId~~ *PUSCH-PathlossReferenceRS-Id* = 1 and closed-loop index l = 1} can be used for TRP2. |
| Lenovo&MotM | We prefer Alt.2. However, considering that the PL-RS of PUSCH is determined by different schemes in different scenarios without SRI field in the scheduling DCI in R15/R16, we think we should consider them separately for PL-RS determination in M-TRP based PUSCH transmission. |
| QC | We only support Alt1. We do not know why the case that SRI-PUSCH-PowerControl is not configured needs to be discussed for mTRP PUSCH.  BTW, it seems that ZTE left the following rule out from the list of Rel. 15/16 rules, which should be the main focus here (it also shows that the claim “When one SRS resource configured in SRS resource set, there is no SRI field in DCI and no SRI-PUSCH-PowerControlId in RRC” in ZTE’s comment above is not correct):  - 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 |
| CATT | We have same view as ZTE and support to update Alt 2 as suggested by LG.  @Qualcomm, the bullet you referred to is under the following condition[R1-2104114]:  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] |
| NTT Docomo | Support FL proposal and alt.2 revised by LG. |
| vivo4 | We agree that the first and second default values of PC parameters except for PL-RS can be utilized for calculating transmit power towards both TRPs when there is no SRI field. For PL-RS, some cases shall be considered specifically. *PUSCH-PathlossReferenceRS-Id* value being equal to zero is used in some cases in Rel-15. *PUSCH-PathlossReferenceRS-Id* value being equal to one can be defined as PL-RS for the other TRP obviously.  As stated in TS 38.213  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  That is, when *enablePL-RS-UpdateForPUSCH-SRS* is configured, if a grant-based or grant-free PUSCH transmission is scheduled/activated by DCI format 0\_1/0\_2 that does not include a SRI field, the RS resource index qd corresponding to the *PUSCH-PathlossReferenceRS-Id* mapped with *sri-PUSCH-PowerControlId = 0* is used for path-loss measurement of PUSCH transmission. In this case, UE expects to be configured with *sri-PUSCH-PowerControl* even there is no SRI field. Therefore, it seems reasonable to derive two default PL-RS from two *sri-PUSCH-PowerControl* associated with two SRS resource set respectively.  So, we would like to add Alt3 to the Proposal 3.3 in FL Update #1 as follows:   * Alt.3 * If the UE is provided *enablePL-RS-UpdateForPUSCH-SRS*, the first set of values {the first value in *P0-AlphaSet*, the PL-RS corresponding to the first *sri-PUSCH-PowerControl* associated with the first SRS resource set and closed-loop index *l* = 0} is used for TRP1, and the second set of values {the second value in *P0-AlphaSet*, the PL-RS corresponding to the first *sri-PUSCH-PowerControl* associated with the second SRS resource set and closed-loop index *l* = 1} is used for TRP2. * Otherwise, the first set of values {the first value in *P0-AlphaSet*, the PL-RS with *PUSCH-PathlossReferenceRS-Id=0* and closed-loop index *l* = 0} can be used for TRP1, and the second set of values {the second value in P0-AlphaSet, the PL-RS with *PUSCH-PathlossReferenceRS-Id* = 1 and closed-loop index *l* = 1} can be used for TRP2. |
| APT/FGI | Support FL’s updated proposal. |

### Proposal 3.4: PT-RS DMRS association

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

* Option 3 (2 bits): 1 bit MSB is used to indicate PTRS-DMRS association for the first TRP, and 1 bit LSB is used to indicate PTRS-DMRS association for the second TRP
  + if *maxNrofPorts* = 1, the 1 bit indicates one of the first two DMRS ports.
  + if *maxNrofPorts* = 2, the 1 bit indicates one of two DMRS ports sharing the same PTRS port.

Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | From performance perspective, we think option 1 is the best. Some more discussion is needed. |
| MediaTek | We can support this proposal. |
| QC | We can support either Option 1 or Option 2, but we do not see Option 3 as a valid / complete solution. Either we support more than 2 layers or not. If we support, the PTRS-DMRS association rule should be also properly designed. |
| Lenovo&MotM | Support. |
| OPPO | Support |
| Samsung | Support FL’s proposal. This method doesn’t increase DCI overhead and it is the unified method for both maxRank ≤2 and maxRank>2. |
| Vivo | Support. |
| ZTE | We have strong concern of this proposal, and RAN1 needs to further assess the rationality of option 3.  For Option 3, it is indeed an incomplete solution which cannot indicate all possible PTRS-DMRS associations. More specifically, when the number of PTRS port is 1, only one of the first two DMRS ports can be selected and associated. Once neither of the first two DMRS ports is the best DMRS port, option 3 will cause performance loss. Likewise, when the number of PTRS port is 2, it means the combination of the two selected and associated DMRS ports is fixed.  For option 1 and option 2, both of them can fully support this enhancement. Differently, option 1 will lead to additional 2 bits DCI overhead, but option 2 will not.  Therefore, we think option 2 should be supported to indicate PTRS-DMRS association when rank > 2, which can guarantee neither DCI overhead increasing nor restrictions of PTRS-DMRS association indication. |
| LG | We don’t agree with the argument that Option 3 is incomplete. It supports PTRS-DMRS association with low resolution by indicating subset of all combination. Even though it cannot indicate best association in some case, as ZTE mentioned, it can still avoid worst association. Also, we don’t see the need of optimizing URLLC PUSCH repetition for rank 3 and 4 since high rank reduces reliability in principle due to inter layer interference and reduced power per layer. |
| NEC | Support the proposal. |
| TCL | We can support this proposal. |
| Xiaomi | We support Option 1, as RAN1 has precluded the limitation of within 2-layer transmission in last meeting, Option 3 should not be considered as a complete solution. It is also not backward compatible for single TRP scenario either. More discussion is needed further on this. |
| Huawei, HiSilicon | We are fine with the proposal. As a compromise, perhaps Option 1 and Option 3 can be configurable. |
| Nokia | We are fine with the proposal if, for maxNrofPorts = 2, Option 3 means the following:   * For each TRP, 1 bit indicates one of two DMRS ports sharing the same PTRS port for two sets of DMRS ports, where each set contains DMRS ports sharing the same PTRS port. The UE then associates the indicated DMRS port in each set to the first and second PTRS ports, respectively.   One alternative for the case maxNrofPorts = 2 is to not support this case, as having two PTRS ports per TRP may not be really justified. |
| Futurewei | Fine with the proposal. |
| Fujitsu | Support FL’s proposal. |
| Ericsson | Support the proposal. We share LG’s view. |
| Intel | Support FL proposal |
| CATT | Support FL’s proposal. |
| FL Update #1 | Majority support the proposal.  Concerns are from Apple, Mtek, QC, Xiaomi.  LG provided some explanations for these companies to rethink and accept the majority view. |
| ZTE2 | With the technical reasons we elaborated before, we do NOT support this proposal so far.  @LG, your comments is a little bit confusing to me. As you said you didn’t agree option 3 is incomplete, then you said option 3 can only indicated subset of all PTRS-DMRS associations, and it can be happened that the best DMRS port will be missed. Based on your above comments, doesn’t it mean that option 3 is an incomplete solution? Regarding rank limitation, hoping you can remember that RAN1 have make a consensus in RAN1 #104-e that maxRank should not be limited in Rel-17 MTRP PUSCH scheme, even we suggested to reach an agreement in #104-e to avoid repeated discussion on this issue but haven’t be adopted. |
| LG | @ZTE, Thanks for the second comment. Maybe we have different understanding of definition of “incomplete” and I think it implies “not working”, but the proposal is working. If you mention it as the proposal cannot cover full combination of PTRS-DMRS association I understand it.  Regarding max rank, as you mention, maxRank is not limited in Rel-17 MTRP PUSCH and that is why we discuss this issue. Rank 3 and 4 can be supported but we don’t see the need of optimizing high rank for URLLC. That is key difference between supporting companies and not supporting companies. |
| Apple | In our understanding, option 3 cannot support full indication. It is hard to say the first and second layer are always the better than the 3rd and 4th layer. Performance wise, this should be the worst compared to option 1 and 2. |
| QC | We can support one of the following, but we cannot support this proposal (option 3), which is the worst option:   * Option 1 * Option 2 * Limit MaxRank to 2   The benefit of Option 1 is simplicity. The benefit of Option 2 is saving DCI overhead. The benefit of limiting maxRank to 2 is that we do not need to discuss this anymore based on some companies input that maxRank>2 is a corner case for mTRP PUSCH.  In option 3, we extend the PTRS-DMRS association to per TRP indication but then we limit it for a given TRP. This does not make sense to us. Then, why not use the same granularity per TRP as in Rel. 15 but apply the same indication to both TRPs (no spec change; just follow Rel. 15)? |
| Xiaomi | Same view as QC, we prefer Option 1. |

### Proposal 3.5: A-CSI on PUSCH

**[Draft for offline] Proposal 3.5.1:** 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).

**[Draft for offline] Proposal 3.5.2:** 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.

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

* No spec impact to clarify this further.

Please comment on preferred changes to the proposals and conclusion.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | For proposal 3.5.1, we suggest to add bullets as follows   * The scheduling offset for the first A-CSI should meet the Z and Z’ requirement   Support proposal 3.5.2.  For conclusion 3.5.3, we are ok to make it as a conclusion, but isn’t it better to change spec to make it clear?  Mod: added bullet on 3.5.1. P 3.5.3 conclusion seems enough. |
| MediaTek | Support |
| QC | For Proposal 3.5.1 and 3.5.2: Support.  For conclusion 3.5.3: Rel. 15 rule itself may first require a clarification. The spec says “An aperiodic CSI report occupies CPU(s) from the first symbol after the PDCCH triggering the CSI report until the last symbol of the scheduled PUSCH carrying the report.” So, it seems that the proper interpretation of Rel. 15 is that CPU occupation duration is until the last symbol of PUSCH (which means that in the case of repetition, it would be the last symbol of the last repetition). This is because spec does not mention “PUSCH repetition”, and the “carrying the report” refers to the PUSCH (which includes all repetitions).  Mod: this is already unchanged for PUSCH repetition scenarios in Rel-15/16, where only the first repetition is used. So the interpretation seems to be PUSCH repetition carrying the report. Also, this may be Rel-15/16 CR is required to further clarify. |
| CMCC | Support. |
| OPPO | Support |
| Samsung | Support. |
| Vivo | For proposal 3.5.1, we think the restriction for gNB to confirm the first and second nominal repetitions be the same as the first and second actual repetitions is unnecessary. For scheduling flexibility, the second nominal repetition will not be used to multiplex A-CSI if the nominal repetition is segmented. So another options can be considered for decision as follows:  [Draft for offline] Proposal 3.5.1: 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 1 or 2 regardless of the indicated number of repetitions. * Option 1: 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). * Option 2: A-CSI is not multiplexed on any repetitions corresponding to the second beam if the second nominal repetition is segmented.   Mod: option 2 seems to be a default condition that we can clarify. |
| ZTE | Support FL’s proposals 3.5.1, 3.5.2, and 3.5.3. |
| LG | We are OK with Proposals 3.5.1 in principle, but instead of saying UE assumes repetition number 2, it should be captured as UE expects repetition number equals to 2. Then, gNB indicates 2 by SLIV field.  Support FL’s proposals 3.5.2, and 3.5.3.  Mod: gNB can not always guarantee these repetitions to be equal to two. So the current version of 3.5.1 is ok. |
| NEC | Support the proposals. |
| TCL | For proposal 3.5.1, when the sequential mapping pattern is applied, the first and second nominal repetitions have the same beam. However, multiplexing the A-CSI on two PUSCH nominal repetitions with the same beam is not appropriate.  For proposal 3.5.2 and conclusion 3.5.3: support.  Mod: we solve this beam mapping case in P.2.3 |
| Spreadtrum | Support the proposals. |
| Xiaomi | Support the proposals. |
| Huawei, HiSilicon | Support FL’s proposals 3.5.1 and 3.5.2. For proposal 3.5.3, we would prefer to further study it considering the different interpretations of the legacy rule mentioned by QC. |
| Nokia | Support the first two proposals. We are fine to further clarify/study the last proposal. |
| Futurewei | Support the proposals and support to further clarify 3.5.3. |
| Fujitsu | Support FL’s proposals. |
| Ericsson | Support FL proposal 3.5.1, in principle. Regarding the first sub-bullet, it would be good to clarify that the number of repetitions refers to the number of repetitions where A-CSI is multiplexed with PUSCH. That is, the number of PUSCH repetitions can be larger than 2, but A-CSI is only multiplexed with PUSCH on two repetitions. See suggested wording below:   * The UE assumes that the number of repetitions where A-CSI is multiplexed with PUSCH is 2 regardless of the indicated number of repetitions.   We support FL proposal 3.5.2.  On proposal 3.5.3, we think the existing workding in 38.214 is fine. But we are ok to study further any clarifications needed to this proposal.  Mod: change on 3.5.1 is used I the update |
| Intel | Support 3.5.1 and 3.5.2. Further discuss 3.5.3 |
| CATT | Support FL’s proposals. |
| FL update #1 | Some comments are added to some responses.  Based on the received comments, P 3.5.1 is updated.  **Proposal 3.5.1:** 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 where A-CSI is multiplexed with PUSCH is 2 regardless of the indicated number of repetitions. * The UE is expected to follow the above operation for multiplexing A-CSI on two PUSCH repetitions only if   + For PUSCH repetition Type B, the first and second nominal repetitions are expected to be the same as the first and second actual repetitions, respectively (no segmentation).   + For PUSCH repetition Type A and B, UCIs other than the A-CSI are not multiplexed on any of the two PUSCH repetitions. * When the UE does not follow the above operation, UE multiplexes A-CSI only on the first PUSCH repetition similar to Rel. 15/16. * The scheduling offset for the first A-CSI should meet the Z and Z’ requirement   **Proposal 3.5.2:** 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.   **Conclusion 3.5.3:** For s-DCI based multi-TRP PUSCH repetition Type A and B, when A-CSI is reported by two PUSCH repetitions, an aperiodic CSI report occupies CPU(s) from the first symbol after the PDCCH triggering the CSI report until the last symbol of the scheduled PUSCH carrying the report (here, the last symbol of the scheduled PUSCH refer to the last symbol of the second PUSCH repetition carrying the report).   * No spec impact to clarify this further. |
| Convida Wireless | OK with FL update #1. |
| Fujitsu | Support the updated FL’s proposal. |
| LG | @Mod: why is that gNB cannot always guarantee these repetitions to be equal to two. Could you elaborate more? Without TB, gNB can trigger A CSI with rep num = 2 in SLIV field through DCI. |
| QC | Proposal 3.5.1: The part “where A-CSI is multiplexed with PUSCH” is not needed (and is confusing). In the case of no TB, there is exactly 2 repetitions. If there is more than 2, what will be transmitted if there is no A-CSI and no UL TB?  Also, this is consistent with Rel. 16 rule:  38.214: when a UE receives a DCI that schedules aperiodic CSI report(s) or activates semi-persistent CSI report(s) on PUSCH with no transport block by a 'CSI request' field on a DCI, the number of nominal repetitions is always assumed to be 1, regardless of the value of numberOfRepetitions  Conclusion 3.5.3: Not clear if a clarification is needed if in Rel. 15, CPU occupation ends after the last symbol of PUSCH (and not the last symbol of the first PUSCH **repetition**). As mentioned before, since spec does not mention PUSCH repetition, it implies that the very last symbol is assumed. If parentheses in the conclusion is removed (same text as Rel. 15 is used), then we are ok (then, companies can bring CR to clarify the Rel. 15 behavior itself). |
| Spreadtrum | For Proposal 3.5.1, we share the same view as QC;  We are OK with Proposal 3.5.2 and conclusion 3.5.3 |
| vivo4 | For Proposal 3.5.1,  Firstly, we don’t know why we need the last bullet, as Rel-15/16 has specified the behavior when Z and Z’ requirement are not met.  In TS 38.214,  When the *CSI request* field on a DCI triggers a CSI report(s) on PUSCH, if the first uplink symbol to carry the corresponding CSI report(s) including the effect of the timing advance, starts earlier than at symbol *Zref*,  - the UE may ignore the scheduling DCI if no HARQ-ACK or transport block is multiplexed on the PUSCH.  When the *CSI request* field on a DCI triggers a CSI report(s) on PUSCH, if the first uplink symbol to carry the *n*-th CSI report including the effect of the timing advance, starts earlier than at symbol *Z'ref(n),*  - the UE may ignore the scheduling DCI if the number of triggered reports is one and no HARQ-ACK or transport block is multiplexed on the PUSCH  - Otherwise, the UE is not required to update the CSI for the *n*-th triggered CSI report.  Secondly, we agree with QC’s clarification and another places with “multiplexing” can be changed to avoid confusion.  **Proposal 3.5.1:** For s-DCI based multi-TRP PUSCH repetition Type A and B, support ~~multiplexing of~~ transmitting A-CSI on the first PUSCH repetition corresponding to the first beam and the first PUSCH repetition corresponding to the second beam when there is no TB carried in the PUSCH.   * The UE assumes that the number of repetitions ~~where A-CSI is multiplexed with PUSCH~~ is 2 regardless of the indicated number of repetitions. * The UE is expected to follow the above operation for ~~multiplexing~~ transmitting A-CSI on two PUSCH repetitions only if   + For PUSCH repetition Type B, the first and second nominal repetitions are expected to be the same as the first and second actual repetitions, respectively (no segmentation).   + For PUSCH repetition Type A and B, UCIs other than the A-CSI are not multiplexed on any of the two PUSCH repetitions. * When the UE does not follow the above operation, UE ~~multiplexes~~ transmits A-CSI only on the first PUSCH repetition similar to Rel. 15/16. * ~~The scheduling offset for the first A-CSI should meet the Z and Z’ requirement~~ |
| APT/FGI | Regarding updated Proposal 3.5.1, we share the same view as QC, i.e., “where A-CSI is multiplexed with PUSCH” is not needed.  In addition, we support Proposal 3.5.2 and conclusion 3.5.3. |

### Proposal 3.6: Dynamic Switching Field

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

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

**[Draft for offline] Proposal 3.6-2:** For the new field in the DCI for dynamic switching,

* Support 2 bits with the following combinations.

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

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

Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support 3.6-1  Support 3.6-2 |
| MediaTek | Support |
| QC | Support both proposals, but is there a need to clarify “first/second SRS resource sets”? For example, when two SRS resource sets with usage set to codebook are configured, there needs to be a clear rule as to which one is “first” and which one is “second” |
| Lenovo&MotM | Support. |
| CMCC | Support. |
| OPPO | Support 3.6-1  Support 3.6-2. Moreover, one restriction is needed to make it work: the same number of SRS resource should be configured in the two SRS resource sets.  Mod. Will capture your suggestion. |
| Samsung | We don’t support proposals.  We think that the bitwidth of new field can be determined depending on existence of the second SRI field to reduce the DCI overhead. If sTRP transmission is indicated, the second SRI field is unused. Therefore, the second SRI field can be re-interpreted to indicate TRP for sTRP transmission if 1 bit new field indicates sTRP transmission. So, except of the case that there is no second SRI field, we can reduce 1 bit for new field.  And we cannot see the strong motivation of TRP ordering. So we think that the proponents need to suggest the more motivation to support TRP ordering.  Therefore, if the second SRI field exists, 1 bit new field is enough to support dynamic switching between mTRP and sTRP (for TRP1 or TRP2). On the other hand, 2 bits new field can be configured when the second SRI field doesn’t exist. This method can be available because the existence of second SRI field is determined by RRC configurations (e.g., the number of SRS resources in the sets…) and, thereby, the bitwidth of new field can be also determined via the RRC configurations.  Mod: This was discussed before and not agreed. |
| Vivo | Support. |
| ZTE | Support FL’s proposals 3.6-1 and 3.6-2.  Noted that there are several new fields to be added in DCI, such as a second SRI field, a second TPMI field, a second TPC field, etc. It means more than 10 bits need to be added in the legacy DCI format 0\_1 / 0\_2, which is terrible but inevitable design. From our perspective, RAN1 should be cautious about any further DCI overhead increasing.  For the sake of DCI overhead saving, whether the new 2-bit field is present in DCI can depend on RRC configuration. Then, except for the case of 1-port based PUSCH repetition, some entries in 2nd TPMI field (for CB scheme) and 2nd SRI field (for NCB scheme) can be used to indicate the STRP/MTRP dynamic switching. After that, always 1 or 2 bits can be saved for most cases.  We suggest to add one proposal as below:  [Draft for offline] Proposal 3.6-3: Whether the new 2-bit field in DCI format 0\_1 / 0\_2 is needed depends on RRC configuration for non-CB/CB based MTRP PUSCH repetition.   * If the new 2-bit field is not configured, one or more entries in 2nd SRI for NCB and 2nd TPMI for CB are used to indicate STRP/MTRP dynamic switching.   Mod: Your suggestion on 3.6.2 was somewhat discussed before and not agreed. |
| InterDigital | We support both FL’s proposal. |
| LG | We support both FL’s proposal. |
| NEC | Not support the proposal. We share similar view as Samsung that when second SRI field exists, there is no need to introduce 2 bits for dynamic switching, when single-TRP is indicated, there are so many second fields not used.  In addition, we share similar view as OPPO that the number of SRS resources should be clarified for the two SRS resource sets, i.e. whether the number should be restricted to be same or not. And we prefer there is no need of such restriction, in other words, the number of SRS resources can be separately configured for the two sets, which can improve the flexibility. For example, regarding NCB transmission, for single-TRP transmission, it’s possible that one TRP can support more number of layers, which will lead to more number of SRS resources in the corresponding set.  Mod: SRS resource issue will be captured. First issue was discussed before and not agreed. |
| TCL | Support FL’s proposals 3.6-1 and 3.6-2. |
| Xiaomi | Support 3.6-1  Support 3.6-2 |
| Fraunhofer IIS/HHI | Support 3.6-1  In 3.6-2, the technical advantage for the change of TRP order is not clear. The last codepoint may not be necessary.  Mod: ordering allows first transmission to receive in TRP1 or TRP2 as network wishes. It is a good flexibility to have. |
| Huawei, HiSilicon | Support FL’s proposals 3.6-1 and 3.6-2. Indicating the order of TRP can also be used for the indication of the beam that applies the TPC command for option 2 in per-TRP closed loop power control, which can reduce 2-bit DCI overhead.  Mod: Let’s not mix proposals. PUCCH does not have this field. |
| Nokia | Support the FL’s proposals |
| Futurewei | Support |
| Fujitsu | Support FL’s proposals. |
| NTT Docomo | Do not support.  Share similar view with oppo that for CB PUSCH, if two SRS resource sets may have different number of SRS resources, with current proposal the size of two SRI fields need to be determined assuming maximum number of SRS resources in two SRS resource sets.  In our view, there is no need to restrict same number of SRS resourcese in two SRS resource sets for CB. For example, 1st SRS resource set may have one SRS resource, while 2nd SRS resource set may have two SRS resources. Thus, we prefer that for CB, 1st SRI field always correspond to 1st SRS resource set, 2nd SRI field always correspond to 2nd SRS resource set.   |  |  |  | | --- | --- | --- | | Codepoint | SRS resource set(s) | SRI/TPMI field (for CB) | | 00 | s-TRP mode with 1st SRS resource set (TRP1) | 1st SRI field/TPMI field | | 01 | s-TRP mode with 2nd SRS resource set (TRP2) | 2nd SRI field  1st TPMI field | | 10 | m-TRP mode with (TRP1,TRP2 order)  1st SRI/TPMI field: 1st  SRS resource set  2nd SRI/TPMI field: 2nd SRS resource set | Both 1st and 2nd SRI/TPMI fields | | 11 | m-TRP mode with (TRP2,TRP1 order)  1st SRI/TPMI field: 1st SRS resource set  2nd SRI/TPMI field: 2nd SRS resource set | Both 1st and 2nd SRI/TPMI fields |   Mod: Oppo mentioned restriction will be added. It seems unnecessary to design different solutions for CB and NCB. The use case of having different resources are not fully justified or recognized by many others. |
| Ericsson | Support FL’s proposals |
| Intel | We prefer to consider the arguments from DOCOMO and OPPO, one option is to support DOCOMO proposal for CB based.  Mod: same comment to DCM. |
| CATT | To save the DCI overhead, we don’t support the proposals.  For CB based PUSCH, if the second TPMI field exists, the second TPMI field can be used to indicate which TRP is transmitted to when signle TRP is indicated. For non-CB based PUSCH, if the second SRI field exists, the second SRI field can be used to indicate which TRP is transmitted to when signle TRP is indicated. Then only 1 bit is needed for the new field on indicating whether the transmission is S-TRP transmission or M-TRP indication.  We support 2-bit new filed only when the second TPMI(for CB based PUSCH)/SRI(for non-CB based PUSCH) field is absent.  Mod: RAN1 progressed from this discussion in last meeting. |
| FL update #1 | Few comments added to the companies with concerns. Updated based on Oppo suggestion.  Good support overall on two proposals.  **Proposal 3.6-1:** Confirm the Working Assumption (with supporting two bits for the new field).   * For indicating STRP/MTRP dynamic switching for non-CB/CB based MTRP PUSCH repetition,   + Introduce a new field in DCI to indicate at least the S-TRP or M-TRP operation.   + The new field is 2 bits   **Proposal 3.6-2:** For the new field in the DCI for dynamic switching,   * Support 2 bits with the following combinations.  |  |  |  | | --- | --- | --- | | **Codepoint** | **SRS resource set(s)** | **SRI (for both CB and NCB)/TPMI (CB only) field(s)** | | 00 | s-TRP mode with 1st SRS resource set (TRP1) | 1st SRI/TPMI field (2nd field is unused) | | 01 | s-TRP mode with 2nd SRS resource set (TRP2) | 1st SRI/TPMI field (2nd field is unused) | | 10 | m-TRP mode with (TRP1,TRP2 order)  1st SRI/TPMI field: 1st  SRS resource set  2nd SRI/TPMI field: 2nd SRS resource set | Both 1st and 2nd SRI/TPMI fields | | 11 | m-TRP mode with (TRP2,TRP1 order)  1st SRI/TPMI field: 2nd SRS resource set  2nd SRI/TPMI field: 1st SRS resource set | Both 1st and 2nd SRI/TPMI fields |  * The SRS resource set with lower ID is the first SRS resource set, and the other SRS resource set is the second SRS resource set. * The same number of SRS resource shall be configured in the two SRS resource sets. |
| Convida Wireless | We don’t support, for the reasons described by Samsung, CATT and others. |
| ZTE2 | We still have strong concern of the further DCI overhead increasing. For the sake of progress, we can live with the following updated Proposal 3.6-1:  **Proposal 3.6-1:** Confirm the Working Assumption (with supporting two bits for the new field).   * For indicating STRP/MTRP dynamic switching for non-CB/CB based MTRP PUSCH repetition,   + Introduce a new field in DCI to indicate at least the S-TRP or M-TRP operation.   + The new field is 2 bits.   + Whether the new field is present in DCI depends on RRC configuration.     - When the new 2-bit field is not configured, one or more entries in some newly added second fields are used to indicate STRP/MTRP dynamic switching for non-CB/CB. |
| Fujitsu | Support the updated proposal and we are also fine with adding a RRC parameter to enable/disable the dynamic switching field. |
| Apple | We do not think the last sub-bullet that “The same number of SRS resource shall be configured in the two SRS resource sets.” is necessary. |
| Samsung | Our proposal is based on the new field in DCI to indicate dynamic switching between sTRP and mTRP. We are suggesting the method to reduce the DCI overhead under the condition. We can consider that 1 bit for new field is enough or not based on the working assumption for new field in the previous meeting (FFS: Whether the new field is 1 bit or 2 bits). In our perspective, 1 bit new field can be utilized for almost cases to indicate dynamic switching.  We are asking to consider the method to reduce the DCI overhead with 1 bit new field if the second SRI (or second TPMI). The second SRI is not used if sTRP transmission is indicated so, we can re-interpret this field to indicate which TRP is used for sTRP transmission. |
| QC | Support the proposal with clarifying the “first/second SRS resource set” as mentioned above:   * 1st SRS resource set is the SRS resource set with a lower ID, and 2nd SRS resource set is the SRS resource set with a higher ID. |
| OPPO | Support the Updated FL proposal. We are also ok with QC’s clarification |
| NEC | We share similar view with DoCoMo and Apple that there is no need to restrict the number of SRS resources to be same in the two SRS resource sets. With separate number of SRS resources, it’s more flexible for scheduling, especially in case of single-TRP transmission, which can be dynamically switched.  And based on current framework, regarding the first and second SRS resource set, we think it’s better to clarify the last two subbullets to be:   * 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 if the two SRS resource sets have same number of SRS resources, otherwise, the SRS resource set with larger number of SRS resources is the first SRS resource set, and the other SRS resource sets is the second resource set. * ~~The same number of SRS resource shall be configured in the two SRS resource sets.~~ |
| CATT | We don’t support the updated proposal. We have same view as Samsung that 1-bit new field can be utilized when the second SRI/TPMI field is present. |
| NTT Docomo | Similar comment as last round. Especially for CB based, we do not see why the restriction of same number of SRS resources in two SRS resource sets is needed.  And If two SRS resource sets may have different number of SRS resources, with current proposal the size of two SRI fields need to be determined assuming maximum number of SRS resources in two SRS resource sets, which cause larger overhead.  Thus, we prefer that for CB, 1st SRI field always correspond to 1st SRS resource set, 2nd SRI field always correspond to 2nd SRS resource set. For NCB, to have more unfied solution, same interpretation as CB can be used except the case of “s-TRP with 2nd SRS resource set”   |  |  |  | | --- | --- | --- | | Codepoint | SRS resource set(s) | SRI/TPMI field (for CB) | | 00 | s-TRP mode with 1st SRS resource set (TRP1) | 1st SRI/TPMI field (2nd field is unused) | | 01 | s-TRP mode with 2nd SRS resource set (TRP2) | 2nd SRI field (1st field is unused)  1st TPMI field (2nd field is unused) | | 10 | m-TRP mode with (TRP1,TRP2 order)  1st SRI/TPMI field: 1st  SRS resource set  2nd SRI/TPMI field: 2nd SRS resource set | Both 1st and 2nd SRI/TPMI fields | | 11 | m-TRP mode with (TRP2,TRP1 order)  1st SRI/TPMI field: 1st SRS resource set  2nd SRI/TPMI field: 2nd SRS resource set | Both 1st and 2nd SRI/TPMI fields |  |  |  |  | | --- | --- | --- | | Codepoint | SRS resource set(s) | SRI (for NCB) | | 00 | s-TRP mode with 1st SRS resource set (TRP1) | 1st SRI field (2nd field is unused) | | 01 | s-TRP mode with 2nd SRS resource set (TRP2) | 1st SRI field (2nd field is unused) | | 10 | m-TRP mode with (TRP1,TRP2 order)  1st SRI field: 1st  SRS resource set  2nd SRI field: 2nd SRS resource set | Both 1st and 2nd SRI fields | | 11 | m-TRP mode with (TRP2,TRP1 order)  1st SRI field: 1st SRS resource set  2nd SRI field: 2nd SRS resource set | Both 1st and 2nd SRI fields | |
| vivo4 | We are fine with **Proposal 3.6-1.**  For Proposal 3.6-2, we share similar views as Docomo after checking the situation. There is no reason to restrict same number of SRS resources in two SRS resource sets both for CB and NCB since it is likely to have Tx panels with different capabilities at UE. However, Docomo’s solution requires separate interpretation tables for CB and NCB which is not favorable. As this is the very first time to discuss the detailed indication table, we suggest to further study the interpretation table considering different number of SRS ports configured in two SRS resource sets. |
| APT/FGI | We support the updated Proposal 3.6-1 and 3.6-2 only if dynamic change of TPR order is supported. If the dynamic change of TPR order is not supported, we don’t think that it makes sense to use two bit-length fields to provide STRP-MTRP switching indication since we still have extra codepoints from 2nd SRI field or 2nd TPMI field to provide extra information, e.g., applying which SRS resource set for STRP transmission. Furthermore, we are also fine with ZTE’s proposal due to DCI overhead issue. |

### Proposal 3.7: Second SRI for NCB-PUSCH

**[Draft for offline] Proposal 3.7:** Confirm the following,

Working Assumption

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



Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Support |
| MediaTek | Support |
| QC | Ok. |
| Lenovo&MotM | Support. |
| CMCC | Support. |
| OPPO | Support |
| Samsung | Support FL’s proposal. |
| Vivo | Support |
| ZTE | Support. |
| InterDigital | We support FL’s proposal. |
| LG | We support FL’s proposal. |
| NEC | We think before we agree this proposal, we need to clarify whether the number of SRS resources can be different for the two SRS resource sets firstly, as we commented in proposal 3.6. |
| TCL | Support. |
| Spreadtrum | Support |
| Xiaomi | Support FL’s proposal |
| Fraunhofer IIS/HHI | Support |
| Huawei, HiSilicon | Support. |
| Nokia | Support |
| Futurewei | Ok with the proposal |
| Fujitsu | Support |
| NTT Docomo | Support |
| Ericsson | Support FL’s proposal. |
| CATT | Support |
| FL Update #1 | Good support.  NEC >> The concern is addressed in the last proposal. |
| Convida Wireless | Support |
| APT/FGI | Support |

### Question 3.8: Second TPMI field for CB-PUSCH

**Question 3.8:** Please indicate your views on supporting PUSCH repetitions transmitting towards multiple TRPs sharing the same TPMI (Here, the presence of the second TPMI field can be separately configured for DCI format 0\_1 and DCI format 0\_2).

|  |  |
| --- | --- |
| Company | Comments |
| Apple | We failed to see spec impact |
| MediaTek | If one of the TRPs cannot use a good TPMI, the gain from M-TRP can be very limited or even worse than single-TRP, especially when the TRP with good TPMI is blocked. We do not support TPMI sharing. |
| QC | Support the proposal as the overhead of the second TPMI can be large (5bits). We can still have mTRP PUSCH (two beams / two sets of PC params) but with a shared TPMI. |
| Lenovo&MotM | Support |
| CMCC | Not support.  Same view with MTK. Improper TPMI cannot guarantee the reliability of Multi-TRP PUSCH repetition. |
| OPPO | We share the similar view as MediaTek |
| Samsung | Not support. |
| Vivo | Support.  There are some use cases as shown in our Tdoc that a single TPMI can still works it depends on the scenario and network configuration. |
| ZTE | We are NOT supportive of this proposal.  In the previous meeting, we provide system-level simulation result in our tDoc (refer to R1-[2102661](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104b-e/Docs/R1-2102661.zip), as shown in Figure 2.2-3) on performance comparison between one same TPMI and two individual TPMIs for CB based MTRP PUSCH, wherein PUSCH is transmitted by the 4 full-coherent ports UE.    Figure 2.2-3: SLS based performance comparison: one same TPMI v.s. two individual TPMIs for CB based MTRP PUSCH repetition scheme  It can be seen that PUSCH repetition over two TRPs with one same TPMI performs much worse than two individual TPMIs. Thus, we fail to see the benefit to support one same TPMI shared towards two TRPs for CB based MTRP PUSCH repetition scheme. |
| InterDigital | Not support, the TPMI should be indicated per TRP. |
| NEC | Do not support. |
| TCL | Share the similar view as MTK. |
| Spreadtrum | Not support |
| Xiaomi | Support this feature in FR1. |
| Vivo2 | @ MediaTek>>  We agree that shared TPMI for PUSCH repetition is not suitable to all cases. But there are some typical use cases of shared TPMI in FR1 where signals transmitted by UE can be received by two cooperating TRPs due to omnidirectional UE antennas and wide-ranged directional TRP antennas in practice.   * + - 1. Joint detection: with joint detection between two TRPs better performance can be obtained compared to separate TPMI, shown in following figure 1.       2. 2Tx UE with non-coherent codebook: the BLER curves in figure 2 are for 2Tx non-coherent codebook which is a typical antenna configuration in commercial UE implementation. We can see that performance of PUSCH repetitions sharing one TPMI is close to PUSCH repetitions using separate TPMI even when separate detection is applied at the receiver.   Therefore, shared TPMI can be supported to reduce DCI overhead at least in such cases.     1. Performance of PUSCH repetitions transmitted towards two TRPs when full/partial/non-coherent codebooks are applied.      1. Performance of PUSCH repetitions transmitted towards two TRPs when only non-coherent codebook is applied.   @ZTE>>  The simulation configuration in your Tdoc is for 4 full-coherent ports UE, and joint detection is not implemented in receiver if our understanding is correct. The simulation result cannot be referred because it is totally not for the use cases of shared TPMI.  You can try the use cases listed above and see whether our simulation results can be aligned. |
| Huawei, HiSilicon | Not support. |
| Nokia | Considering the DCI overhead, it would make sense to give the NW the flexibility whether to configure a second TPMI field or not. |
| Futurewei | Fine to further study the scenarios proposed by vivo, but we wonder if these are really “typical” or not, or maybe how typical they are. |
| MediaTek2 | @vivo>>  Thanks for discussion. From your tdoc, we assume joint detection means that the same repetition can be received by both TRPs, then we agree that it works well in FR1. However, it can already be supported by the current spec. Since it is the same signal to be received by two TRPs, all parameters, e.g., TPMI and transmission power, can be identical and there is no need to distinguish two TRPs. As for the 2nd bullet, we are unsure which factor is needed by introducing a shared TPMI scheme instead of simply using the existing R15 slot aggregation for UL and up to gNB implementation for detection. |
| Ericsson | Do not support. |
| vivo3 | @ MediaTek>>  Thanks for the comment. We think using a single transmit power to transmit the PUSCH repetitions to different TRP as R15/16 would either cause worse performance with the power control referring to the TRP of less pathloss, or cause power waste and higher inter-UE interference with the power control referring to the TRP of larger pathloss. So PUSCH repetition under R15/16 signaling in MTRP scenarios is not an efficient solution.  Per joint reception in FR1, MTRP PUSCH repletion in R17 with shared TPMI has opportunity to adjust proper transmit power for PUSCH repetitions towards different TRPs, which can keep a good balance among the performance, power efficiency, and inter-UE interference.  For 2Tx UE with non-coherent codebook cases assuming separate detection, the above-mentioned benefit of tradeoff among the performance, power efficiency, and inter-UE interference can also be obtained by applying different power control parameters without much loss of performance, not to mention the saved DCI overhead. We believe the performance is still maintained in FR2 where different SRIs should be indicated. |
| CATT | Not support |
| FL update #1 | No FL proposal on this. |
| Convida Wireless | Not support |
| APT/FGI | Due to the signaling overhead reduction, we can support. However, we only support this feature in FR1. If we support PUSCH repetitions transmitting towards different TRPs sharing the same TPMI in FR2, it will result in large performance loss. |

### Proposal 3.9: CG PUSCH – RV mapping

**[Draft for offline] Proposal 3.9:** For RV mapping of type 1 or type 2 CG based multi-TRP PUSCH repetition,

* The configured RV sequence (via “*repK-RV*”) is applied separately for PUSCH repetitions corresponding to the first TRP and the second TRP with a possibility of configuring an RV offset for the starting RV corresponding to the second TRP (similar to the case of dynamic multi-TRP PUSCH repetition).
* FFS1: How the *startingFromRV0* is associated with the initial transmission of a TB corresponding to each TRP.

Please comment on preferred changes to the proposal. FFS1 needs more inputs.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Do not support to configure an RV offset for the second TRP. Such RV offset is a kind of fixed configuration, since it is based on RRC. So we do not see any benefit to configure the RV offset. |
| MediaTek | Support |
| QC | Support the proposal to unify the design with the DG case. In addition, if the RV offset is not introduced, then additional repK-RV sequences need to be introduced for the second TRP (with larger RRC overhead, and unnecessary discussions of the choice of the second sequence). |
| CMCC | Support. |
| OPPO | Share the same view as Apple |
| ZTE | Share the same view as Apple and OPPO. |
| LG | Support. |
| NEC | Support. |
| TCL | Share the same view as Apple. In addition, a second configured RV sequence (e.g. repK-RV2) can be applied to transmission occasions associated to the second TRP. |
| Spreadtrum | Fine |
| Xiaomi | We can’t see the benefit from configuring a RV plus offset for a second TRP.  We suggest to configure two RV sequences for the CG PUSCH to apply different RV sequences for different sets of Tos related to different TRPs, which provides more flexibility for the gNB scheduler. |
| Fraunhofer IIS/HHI | Support |
| Huawei, HiSilicon | Share the same view as Apple. |
| Nokia | Support the proposal |
| Futurewei | Open for further discussion |
| Fujitsu | Support FL’s proposal. |
| Ericsson | Support FL’s proposal. |
| Intel | Support |
| CATT | Support the proposal in principle. However, in this proposal, it seems that the sentence “a possibility of configuring an RV offset” can be interpreted in two ways:   * Interpretation 1: whether the RV offset is supported or not is to be discussed * Interpretation 2: RV offset is optionally configured for M-TRP PUSCH transmission   If it means interpretation 2, i.e. it is possible that the RV offset for the second TRP is not configured for M-TRP transmission, in such case, the RV sequence for the second TRP should be specified.  To avoid such ambiguity, we suggest to revise the proposal as follows:  [Draft for offline] Proposal 3.9: For RV mapping of type 1 or type 2 CG based multi-TRP PUSCH repetition,   * The configured RV sequence (via “*repK-RV*”) is applied separately for PUSCH repetitions corresponding to the first TRP and the second TRP with a ~~possibility of configuring~~ an RV offset for the starting RV corresponding to the second TRP (similar to the case of dynamic multi-TRP PUSCH repetition). * FFS1: How the *startingFromRV0* is associated with the initial transmission of a TB corresponding to each TRP. |
| FL Update #1 | Majority support the proposal.  Apple, oppo, ZTE, TCL, Xiaomi, HW has concerns. Updated to capture some views.  Proposal 3.9: For RV mapping of type 1 or type 2 CG based multi-TRP PUSCH repetition, select one from the following,   * Alt.1: The configured RV sequence (via “*repK-RV*”) is applied separately for PUSCH repetitions corresponding to the first TRP and the second TRP with a ~~possibility of configuring~~ an RV offset for the starting RV corresponding to the second TRP (similar to the case of dynamic multi-TRP PUSCH repetition). * Alt.2: The configured RV sequence (via “*repK-RV*”) is applied separately for PUSCH repetitions corresponding to the first TRP and the second TRP. * Alt.3: Up to two RV sequences can be configured. If one RV sequence is configured, the same RV sequence is applied separately for PUSCH repetitions corresponding to the first TRP and the second TRP. If two configured RV sequences are configured, RV sequences are applied separately for PUSCH repetitions corresponding to the first TRP and the second TRP. * FFS1: How the *startingFromRV0* is associated with the initial transmission of a TB corresponding to each TRP.   FL proposal is Alt. 1.  Alt. 2 and 3 does not have added benefit compared to Alt.1 and already used for Rel-16 PDSCH, Rel-17 DG PUSCH enhancements. More importantly, FL needs inputs on how this works together with *startingFromRV0.* |
| ZTE2 | We prefer to Alt 2. |
| Fujitsu | Support the updated FL’s proposal and prefer Alt.1.  For FFS1, *startingFromRV0* is associated with the initial transmission of a TB corresponding to each TRP only if the RV offset = 0; otherwise, Rel-16 UE behavior is applied. |
| Apple | In our understanding, by default this is Alt2. The whole proposal may not be needed. |
| MediaTek | We support Alt 1. |
| QC | Support Alt1. |
| Spreadtrum | We are fine with Alt.1 |
| OPPO | We prefer Alt.2 |
| Xiaomi | Currently 3 RV sequences (other RV sequences are not precluded for multi-TRP scenario) can be configured for CG PUSCH for single TRP scenario. Different RV sequence has different advantages, e.g. {0231} has more combining gain for Chase Combining, {0000} has more self-decodable opportunities. Alt.2 is the default setting of alt.1&alt.3 which provides the least flexibility. With applying different RV sequence such as {0303} to one of the TRPs other than RV{0231}, more opportunities would be provided for data transmission from transmission occasion with RV=0. To enable more flexibility to the scheduler, we prefer alt.3. |
| CATT | Support Alt 1. |

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

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

* No spec impact

Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | As we proposed, PT-RS to DMRS port association cycling could provide better performance. The associated DMRS port index for a PT-RS port should be selected based on the repetition index.  This proposal 3.10 should be the worst from performance perspective. |
| MediaTek | Support |
| QC | Support. Anyway, the current rule in the spec is enough (no enhancement is needed; hence, the discussions can be also skipped). |
| CMCC | Support. |
| OPPO | Support FL’s proposal. |
| Vivo | Support. |
| ZTE | Support FL’s proposal. |
| InterDigital | We support FL’s proposal. |
| LG | We support FL’s proposal. |
| NEC | Support |
| TCL | Support FL’s proposal. |
| Spreadtrum | Support |
| Xiaomi | We think PTRS cycling can also be considered for CG PUSCH, more discussion is preferred. |
| Huawei, HiSilicon | We are fine with FL’s proposal. |
| Nokia | Support the FL’s proposal |
| Futurewei | Support |
| Fujitsu | Support FL’s proposal. |
| Ericsson | Support FL’s proposal |
| Intel | Support |
| CATT | Support |
| FL update #1 | The proposal has a very good support. Apple and Xiaomi to confirm. |
| Apple | As we commented, port cycling should be better, which can achieve diversity gain, as we cannot make sure the first port is always the best. |
| Xiaomi | We think cycling can be a better choice than the default port of the legacy solution. |

### Proposal 3.11: CG PUSCH remaining details

**[Draft for offline] Proposal 3.11:** For type 2 CG based multi-TRP PUSCH repetition:

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

Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | We think it is better to use the same approach as DG-PUSCH, so that the power control parameters are associated with indicated SRIs in activating DCI |
| MediaTek | Support |
| QC | Support. |
| Lenovo&MotM | Suupport. |
| CMCC | Support. |
| OPPO | Support FL’s proposal. |
| Vivo | Support. |
| ZTE | Support FL’s proposal. |
| InterDigital | We support FL’s proposal. |
| LG | We support FL’s proposal. |
| NEC | Support the proposal. |
| TCL | Support FL’s proposal. |
| Spreadtrum | Support |
| Xiaomi | Support |
| Huawei, HiSilicon | We are fine with FL’s proposal. |
| Nokia | Support |
| Futurewei | Support |
| Fujitsu | Support FL’s proposal. |
| Ericsson | Support |
| CATT | Support |
| FL update #1 | Almost all support the proposal. Apple to check this again carefully the third sub-bullet. SRIs and new DCI field on switching also applicable here. |
| Apple | OK with the proposal |
| Lenovo&MotM | Support. |
| APT/FGI |  |

### Proposal 3.12: FH and beam mapping for PUSCH

**[Draft for offline] Proposal 3.12:** For inter-repetition frequency hopping with PUSCH repetition Type A or Type B, frequency hopping is performed among the repetitions associated with the same TRP when the cyclical mapping pattern is configured.

Please comment on preferred changes to the proposal.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | Suggest removing “when the cyclical mapping pattern is configured” |
| MediaTek | Do not support. Sequential mapping in combination with inter-repetition FH is sufficient. The order of frequency diversity and beam diversity is not essential. |
| QC | Support the proposal. This proposal may also be considered together with Proposal 2.4 (for PUCCH) |
| Lenovo&MotM | Support. |
| CMCC | Support. |
| OPPO | Not support. The additional benefit of this proposal is questionable. We prefer Option 3 as it does not have spec impact. |
| Samsung | Support in principle. |
| Vivo | We do not support the proposal. Same reasoning as PUCCH. |
| ZTE | Support FL’s proposal. |
| InterDigital | We should have a unified solution with Proposal 2.4. |
| LG | Support FL’s proposal. |
| Xiaomi | Support in principle. |
| Huawei, HiSilicon | Not support, with the same reasoning as proposal 2.4. |
| Nokia | We don’t support (for the same reasons as PUCCH). |
| Futurewei | Given 2.4, this may not be needed. |
| Fujitsu | Support FL’s proposal. |
| Ericsson | Support in principle. |
| Intel | Good to align with 2.4 |
| CATT | For PUSCH transmission with repetition number larger than 2, we support FL’s proposal. For PUSCH transmission with repetition number equals to 2, we support slot level FH. |
| FL update #1 | This can be discussed after deciding on PUCCH proposal. Please let me know if that is not the case. |
| Convida Wireless | Support in principle. |
| APT/FGI | Support FL’s proposal |

## 3.3 Additional high priority proposals

In this FL summary, I have not included any FL proposals based on certain other directions that were discussed before and have not had consensus or progress. If companies wish to bring any additional aspects related to PUSCH during RAN1 #105-e, please comment below.

|  |  |
| --- | --- |
| Company | Comments |
| Apple | We suggest to discuss the issue on P/SP-CSI report on mTRP PUSCH |
| vivo | * Clarify information field interpretation when the number of information field(s) of the UL BWP indicated by BWP indicator field is different from the required number of information field(s) of current active BWP. * Clarify whether two SRS resource sets are configured for both DCI format 0\_1 and 0\_2 or not. * Support configuration of the enhanced field(s) per DCI format, i.e., whether the enhanced fields are present or not is configured for DCI format 0\_1 and DCI format 0\_2 separately. * How to indicate PC parameter set by the second SRI field for non-codebook PUSCH. |
| ZTE | Based on FL’s assessment in section 3.1, per TRP DMRS sequence initialization can be enhanced for both DG-PUSCH and CG-PUSCH in this meeting. |
| LG | We suggest to discuss beam switching gap issue when only one of multiple panels is activated. Due to panel activation delay, in this case UE cannot support back-to-back PUCCH/PUSCH repetition. |
| NEC | Regarding CB transmission, we suggest to clarify whether the maximum number of Rank can be different for different TRPs, we think for single-TRP transmission, one TRP can support more number of layers than another single-TRP. |
| Huawei, HiSilicon | We also suggest to discuss the issue on P/SP-CSI report on mTRP PUSCH, especially in case of collision between PUCCH and PUSCH. |
| Futurewei | TA should be discussed. All UL aspects, including separate PC, separate BM, two precoding, etc., have been covered, but no discussion of UL TA, a critical aspect for UL. We have shown in our tdoc that without proper TA, UL transmissions will fail. We also noticed that in RAN2 L1/L2 Scenario 1 (M-TRP like scenarios) discussions, TA issues have been asked by multiple companies. This has to be studied and discussed. |
| Ericsson | We prefer to discuss SP-CSI repetition over mTRP PUSCH. |
| FL Update #1 | We can check P/SP-CSI report on mTRP PUSCH if time allows after other proposals. |
| LG | Same comment as Section 2.3 |
| CATT | We suggest to discuss whether M-TRP repetition for PUSCH scheduled by DCI format 0\_0 can be supported.  If M-TRP repetition for PUSCH scheduled by DCI format 0\_0 is supported, the spatial relation of the PUSCH can be determined by the PUCCH resource with the lowest ID   * if the PUCCH resource with the lowest ID is activated with two spatial relation info’s, the number of transmission occasions of the PUSCH is two, and each occasion is associated with one spatial relation info; * otherwise, the number of transmission occasion of the PUSCH transmission is 1, and the spatial relation info with lower ID is used as the default beam for PUSCH scheduled by DCI format 0\_0. |
|  |  |

# Reference

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

# 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 RB  PUCCH Format 3: 4 and 8 symbols, 1 RB  Other 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 | TDM  Details 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 1  DM-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 | TDM  Details 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.

## 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,

* 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*'.