**3GPP TSG-RAN** **WG2 Meeting #114 electronic R2-21xxxxx**

**Online, 19 – 27 May, 2021**

**Source: Samsung**

**Title: Summary of [AT116-e][016][feMIMO] MAC CE impacts (Samsung)**

**Document for: Report and Decision**

**Agenda Item: 8.17.3**

# Introduction

This document summarizes the following email discussion.

* [AT116-e][016][feMIMO] MAC CE impacts (Samsung)

Scope: Based on R2-2110962, R2-2110035, RAN LS’s and RAN1 progress. Do an initial review of impacts to MAC (MAC CEs) and related R2 work, collect initial comments, assess maturity and if possible Find Potential Agreements, identify points for online discussion, can also identify open issues.

Intended outcome: Report

Deadline: For online W1 Thursday

The intention of this offline discussion is reviewing impacts to MAC CEs on RAN1 LSes and their consequences/agreements. As results of this offline discussion, RAN2 will find Easy/Potential Agreements, identify points for online discussion, can also identify and capture open issues, and whether LS out is needed.

# Contact Points

Respondents to the email discussion are kindly asked to fill in the following table.

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# Discussion:

## Uplink MAC CE enhancements for multi-TRP operations

Based on RAN1 agreements captured in [4], there are some issues regarding potential MAC CE enhancements/introduction. These issues are related to the uplink enhancement to enhance the reliability features for mTRP operation (e.g. PUCCH repetition, PUSCH repetition, etc.) which is listed in feMIMO WID [1]. In addition, some RRC impacts about uplink enhancements are provided in [5].

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| 1. 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 |

Below summarized issues have been identified in [4] in terms of expected UL MA CE enhancements:

* + - 1. PUCCH related issues
         * Issue 1-1: How to enhance/design PUCCH spatial relation activation/deactivation MAC CE for mTRP PUCCH repetition
         * Issue 1-2: How to support per-TRP power control in FR1;
      2. PUSCH related issues
         * Issue 2-1: How to enhance/design pathloss reference RS update MAC CE for mTRP PUSCH repetition
         * Issue 2-2: How to enhance/design PHR reporting MAC CE for mTRP PUSCH repetition

### 3.1.1 PUCCH spatial relation activation/deactivation MAC CE for mTRP PUCCH repetition

RAN1 agreed to introduce the multi-TRP PUCCH repetition in Rel-17 (i.e. each PUCCH resource can be associated with one or two spatial relations and support simultaneous activation/deactivation of spatial relations in a PUCCH groups).

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| **RAN1#106-e Agreements**  **Agreement**  For the grouping of PUCCH resources in Rel-17 multi-TRP PUCCH repetition schemes,   * Support MAC-CE activating two spatial relation info’s (for FR2) for a group of PUCCH resources in a CC. * Support MAC-CE activating two sets of power control parameters (for FR1) for a group of PUCCH resources in a CC. * When the PUCCH resource is indicated with two spatial relation info’s or two sets of power control parameters (via a MAC-CE that activating two spatial relation info’s or a MAC-CE that activating two sets of power control parameters for a group of PUCCH resources, respectively), the other PUCCH resources in the group also get updated to have the same two spatial relation info’s or two sets of power control parameters. * When the PUCCH resource is indicated with one spatial relation info or one set of power control parameters (via a MAC-CE that activating single spatial relation info or a MAC-CE that activating single set of power control parameters for a group of PUCCH resources, respectively), then the other PUCCH resources in the group also get updated to have the same spatial relation info or the same set of power control parameters. * The signalling details are up to RAN2 to decide. * Note: Impacts coming from coverage enhancement work item on associating PUCCH resource with repetition factor can be discussed separately |

As captured in above, some enhancements on “Enhanced PUCCH Spatial Relation Activation/Deactivation MAC CE” to support multi-TRP PUCCH repetition scheme seem required.

**Q1: Do you agree to enhance the “Enhanced PUCCH Spatial Relation Activation/Deactivation MAC CE” to support multi-TRP PUCCH repetition scheme in Rel-17?**

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| **Company name** | **Comments** |
| LGE | Yes, but we think it is enough not to apply the restriction in the current specification than to change the MAC CE format.  The details are answered in Q2. |
| Ericsson | yes |
| Qualcomm | Yes |
| Samsung | Yes |
| OPPO | Yes |
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**Rapporteur summary**

**TBD**

In [4], there are two candidate approaches to support this feature:

1. Option 1: Introduce the new PUCCH spatial relation activation/deactivation MAC CE for mTRP PUCCH repetition.
2. Option 2: Revise the legacy “Enhanced PUCCH Spatial Relation Activation/Deactivation MAC CE” with additional fields (e.g. indicator for mTRP operation, additional Spatial Relation Info ID(s) for added TRP).
3. Option 3: Others

**Q2: If yes for Q1, which option is preferred to support PUCCH spatial relation activation/deactivation MAC CE for mTRP PUCCH repetition? (i.e. activate/deactivate one or two spatial relations for a group of PUCCH resources).**

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| **Company name** | **Option** | **Comments** |
| LGE | Option 3 | We think the reuse of legacy MAC CE is the simplest way.  There is a restriction not to include PUCCH Resources within the same PUCCH Resource group in one MAC CE.   * no other PUCCH Resources within the same PUCCH Resource group are indicated in the MAC CE.   If the restriction is not applied for the multi-TRP PUCCH repetition applicable UE, multiple PUCCH Resources within the same PUCCH Resource group can be included in one MAC CE, and multiple Spatial Relation Info can be included in the MAC CE, i.e., multiple Spatial Relation Info can be activated in the same PUCCH resource group by the MAC CE. |
| Ericsson | Option 1 | Main point is the functionality but also clarity is important.  It seems simpler to have new MAC CE rather than trying to reuse R field in an existing MAC CE and explain another interpretation of the fields as the other interpretation would mean that per one PUCCH resource up to two spatial relation IDs follow. Thus, the interpretation of the field would mean restructuring of the rest of the fields.  The suggestion to lift the restriction related to PUCCH group results in mixing two concepts, mTRP and BM as PUCCH group can have multiple, more than one PUCCH resource and these resources are not per TRP/in relation to a TRP. |
| Qualcomm | Option 2 | The legacy MAC CE (6.1.3.25 in 38.321) can be revised to support new requriment, i.e. activate/deactivate one or two spatial relations and for a group of PUCCH resources.  The legacy restriction should be kept for new MAC CE, otherwise, updating the spatial relation for the PUCCH resource within one group may not work. |
| Samsung | Option 1 | Both options can work but we think the new MAC CE could be well-designed for the newly added functionality.  We agree with Ericsson’s comments above. |
| OPPO | Option 2 | The RAN1 agreements also show that the same restriction could be applied for the mTRP case i.e. PUCCH resource within same group share same spatial relationship. So we think legacy MAC CE can be reused as such that one PUCCH Resource ID can be linked with two different Spatial Relation Info ID. |
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**Rapporteur summary**

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### 3.1.2 Association between PUCCH and TRP for PUCCH multi-TRP enhancements in FR1

RAN1 agreed that the linking of PUCCH resource with two power control parameter sets is required in case of FR1 mTRP operation (i.e. spatial relation activation/deactivation) in Rel-17.

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| **RAN1#104-e Agreements**  **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. |

Based on explanation in [4], RAN1 also provides their view how to handle this issue, i.e. reuse *PUCCH-SpatialRelationInfo* IE except for the *referenceSignal* in case of FR1. It means the same MAC CE what used for FR2 could be used to activate/deactivate the spatial relation for FR1 as well. If RAN2 accept the suggested signling what RAN1 suggested, there would be no MAC CE issues but only have RRC impacts e.g. restrictions in field description. Or, the new MAC CE for spatial relation update (with power control) for FR1 case could be introduced.

**Q3: Which option is preferred to support spatial relation update (with power control) for FR1?**

1. Option 1: Reuse the legacy MAC CEs (Enhanced PUCCH Spatial Relation Activation/Deactivation MAC CE and MAC CE could be introduced as a result of Q1/Q2) to FR1 case as well.
2. Option 2: Introduce the new MAC CE(s) to support spatial relation update (with power control) for FR1 cases.
3. Option 3: Others
4. Option 4: Introduce the new MAC CE(s) to support PUCCH Power control set update (with power control) for FR1 cases.

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| **Company name** | **Option** | **Comments** |
| LGE | Option 1 | In RAN1 agreement in RAN1#104-e, RAN1 has already given the example of what they think, i.e., *reuse PUCCH-SpatialRelationInfo except for the referenceSignal*. |
| Ericsson | Option 4 | Note that the suggestion from RAN1 is just an example, and the exact design of the signaling is up to RAN2. What needs to be enhanced according to the above RAN1 agreement is to *link a PUCCH resource with either one or two power control parameter sets for FR1.*  *Currently there is no need to configure spatial relations to a UE in FR1.* For this reason, we do not prefer reusing PUCCH-spatialRelationsInfo to configure the power control parameter sets. The power control parameter sets for PUCCH can be configured separately from PUCCH-SpatialRelationInfo.Further, there is no reason to introduce new MAC CE that has spatial relation functionality as that is not needed for FR1.  Finally, power control and spatial relation are separate functionality, it is cleaner to have separate MAC CE for PUCCH power control even if FR1 would use spatial relations.  For the reasons above we added the Option 4:  Introduce the new MAC CE(s) to support PUCCH Power control set update (with power control) for FR1 cases. |
| Qualcomm | Option 2, but | Legacy MAC CE (6.1.3.25 in 38.321) cannot indicate two sets of power control parameters.  The MAC CE format can reuse the one in Q2 instead of the legacy, and the signaling restriction suggested by RAN1 can be described accordingly if RAN2 accept, i.e. reuse PUCCH-SpatialRelationInfo IE except for the referenceSignal in case of FR1.  Further, no need to configure spatil relations to UE in FR1, the option 2 should be updated. -- to support PUCCH Power control set update for FR1 case. |
| Samsung | Option 1 | We don’t see big motivation to separately handle the FR1 case.  As RAN1 suggested, some RRC restriction could be enough.  For Qualcomm’s comment that legacy MAC CE cannot indicate two sets of power control parameters, the intention of Option 1 is reuse both legacy MAC CE (6.1.3.25 in 38.321) and the new MAC CE format will be introduced as outcome of Q2 for FR1 case.  In addition, we think the power control set can be implicitly indicated by spatial relation info. if SpatialRelationInfo IE includes corresponding power control parameters. |
| OPPO | Option1 | We agree with E/// that for FR1 no spatial relationship to UE for FR1. But we think RAN1’s suggestion can be easily adopted in RAN2 considering current power control parameter within PUCCH-SpatialRelationInfo can be linked by MAC CE between PUCCH Resource ID and pucch-SpatialRelationInfoId for FR1 in MAC layer.However some clarification in RRC spec is needed. |
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**Rapporteur summary**

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### 3.1.3 PHR reporting for mTRP PDSCH repetition

For PHR reporting related to mTRP PUSCH repetition, RAN1 agreed the below baseline:

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| **RAN1#106-e Agreements**  Agreement  For PHR reporting related to M-TRP PUSCH repetition, support Option 4 as UE optional capability for a UE that supports mTRP PUSCH,   * Option 4: Calculate two PHRs (at least corresponding to the CC that applies m-TRP PUSCH repetitions), each associated with a first PUSCH occasion to each TRP, and report two PHRs.   **RAN1#106bis-e Agreements**  **Agreement**  If a UE does not support option 4 (Calculate two PHRs),   * If the PHR reporting is actual PHR, the UE uses the set of power control parameters corresponding to a first (earliest) repetition that overlaps with the first slot in which the PUSCH that carries the PHR MAC-CE is transmitted. * If the PHR reporting is virtual PHR, it is reported based on legacy procedures. * Note: RAN2 may further discuss PHR triggering aspects related to mTRP PUSCH repetition |

Based on RAN1 agreements, there are two possibilities that UE reports PHR for mTRP PUSCH repetition.

1. If UE support PHR reporting related to mTRP PUSCH repetition (Calculate two PHRs)
2. If UE doesn’t support PHR reporting related to mTRP PUSCH repetition (Calculate two PHRs)

It seems RAN2 need to further discuss how to support PHR reporting related to mTRP PUSCH repetition because RAN1 already agreed the schems on PHR for mTRP PUSCH repetition.

**Q4: Do you agree to introduce the new MAC CE regarding PHR for mTRP PUSCH repetition?**

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| **Company name** | **Comments** |
| LGE | Yes. For "calculate two PHR" capable UE, we think the new MAC CE is essential. |
| Ericsson | Yes. If UE needs to calculate two PHRs and report those the MAC CE should either send one at the time and indicate which TRP(coreset ID or another indentifying ID from RRC) it is for or send PHR for both TRPs in same MAC CE. |
| Qualcomm | Yes, for UE with capability of calculate two PHR |
| Samsung | Yes, for UE with capability of calculate two PHR |
| OPPO | Yes |
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**Rapporteur summary**

**TBD**

In [4], RAN2 is requested to discuss how to support PHR reporting related to mTRP PUSCH repetition, and provides some considerable issues as below:

* + - * + New MAC CE design including the function which TRP is applied for PHR reporting.
        + How to handle if both MAC CEs are pending and UL grant is not large enough to accommodate both the MAC CEs.
* UE implementation
* one MAC CE have priority of the other (e.g. original PHR MAC CE has high priority)
* Network can indicate which TRP’s PHR has higher priority
  + - * + Whether use legacy parameters (timer, threshold, etc.) or adding TRP specific parameters
        + PHR triggering conditions

**Q5: If yes for Q4, do you agree the potential issues identified above? Please add further issues if you think necessary from RAN2 perspective.**

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| **Company name** | **Comments** |
| LGE | Agree with the design and handling of new MAC CE. However, we think the separate timer is not needed even TRP specific PHR is introduced, but RAN2 may ask RAN1 whether TRP specific threshold and TRP specific triggering condition are needed. |
| Ericsson | We agree MAC CE work is needed.  Then for second point, considering priority is ok especially for intercell case where there will be the original serving cell TRP and the added PCI TRP.  Having separate parameter configuration would provide more network flexibility as if same value is preferred, network can configure such.  For PHR triggering, per TRP triggering should be applied. |
| Qualcomm | It is unclear for us the second bullet. Why both the new PHR MAC CE and the legacy MAC CE are pending? If UE doesn’t support to report new PHR MAC CE, UE follows the legacy triggering condition and sends the legacy PHR MAC CE.  Whether separate parameter configuration for PHR is needed or not needs FFS. |
| Samsung | Agree what provided above.  We believe many detail procedure should be further discussed by RAN2. |
| OPPO | We also think some clarification from RAN1 is needed about what is the dependency of the parameters between two PHR. |
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**Rapporteur summary**

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### 3.1.4 Pathloss Reference RS update MAC CE for mTRP

In Rel-17, RAN1 has introduced PUSCH repetition for mTRP, so it is required to enhance PUSCH Pathloss Reference RS Update MAC CE to support mTRP. It needs to be indicated which TRP is applied for this MAC CE i.e. adding TRP indication or SRS resource set associated with TRP information.

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| **RAN1#104-e Agreements**  **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. |

In [4], two candidate approaches have been provided to support this feature:

1. Option 1: Introduce the new PUSCH Pathloss Reference RS Update MAC CE for mTRP PUSCH repetition.
2. Option 2: Revise the legacy PUSCH Pathloss Reference RS Update MAC CE with additional field to differentiate the TRP information.
3. Option 3: Others

**Q6: Which option is preferred to support Pathloss Reference RS update MAC CE for mTRP?**

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| **Company name** | **Comments** |
| LGE | Option 2. Currently, there are two R bit in PUSCH Pathloss Reference RS Update MAC CE. We think it would be simple to replace R bit to one indicator. |
| Ericsson | Option 2. For this case it seems simpler to revise the existing MAC CE. The description would be simply that the revised field tells which TRP(SRS set ID or another indentifying ID from RRC) the update is for and not about structure of the MAC CE as it would be for the case in Questions Q2. |
| Qualcomm | Option 2 but.  6.1.3.28 of 38.321 can be revised to support new requirement. In addition to the new field to indicate the TRP information, another inciation bit is also needed to enable whether two SRS resource set associated SRI IDs are both updated. |
| Samsung | No strong view (Slightly prefer Option 2).  But we agree that reusing the legacy MAC CE is simple so Option 2 seems beneficial. |
| OPPO | Option2 assuming RAN1’s intention is that the association to 1st or 2nd SRS resource set is applicable for all SRI ID within the same MAC CE which is our understanding. |
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**Rapporteur summary**

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## Other MAC CE enhancements

According to LSes [2][3] from RAN1, some MAC CE enhancements regarding inter-cell beam management are required, see relevant RAN1 responses:

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| **Question 1: RAN2 notes that WI objective 1 states " The same beam measurement/reporting mechanism will be reused for inter-cell mTRP "). RAN2 would like to understand if the entire inter-cell BM is also applicable to inter-cell mTRP? If not, which part is not applicable to mTRP and how does that work?**  **Answer 1**: Rel17 Inter-cell BM and inter-cell mTRP have common points but they are not entirely the same. The common and different points are as follows: they both use the same beam measurement/reporting mechanisms but they have different TCI signaling framework (beam indication) as inter-cell BM is based on Rel17 unified TCI while inter-cell mTRP is based on Rel15/16 TCI framework. For inter-cell BM, UE assumes that the UE-dedicated channels/RSs can be switched to a TRP with different PCI according to DCI/MAC-CE based unified TCI update; for inter-cell mTRP, UE assumes mDCI-mTRPbased multi-PDSCH reception.  f) **TCI switching signalling:** Which signalling should be used for TCI switching for inter-cell beam management?  **Answer 2.f**: Inter-cell beam management is going to use Rel-17 unified TCI signaling where RAN1 agreed that a MAC-CE activates one or multiple TCI states out of RRC configured TCI state pool. If multiple TCI states are activated, DCI selects one TCI state among activated ones. If only one TCI state is activated, the activated TCI state is also implicitly selected without further DCI indication. |

In addition, [5] provides the analysis on the User plane impact of inter-cell beam management but it seems there are no further MAC CE impacts other than above issues. One further required MAC CE would be mTRP BFR related MAC CE which has been discussed in other offline discussion.

We think the detail MAC CE discussion for both TCI update for inter-cell mTRP and mTRP BFR will be discussed in other offline discussion.

**Q7: Are there further MAC CEs to be introduced in Rel-17 other than both inter-cell mTRP and mTRP BFR MAC CEs?**

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| **Company name** | **Comments** |
| LGE | No. Not needed anything other than the new PHR and some enhancements mentioned above. |
| Ericsson | For BM the mTRP enhancements that consider indicating two TCI states/spatial relations, power control or PHR are not relevant. PCI is hidden in TCI state thus apart from checking that ID spaces do not change, the TCI state related MAC Ces of Rel-16 should work.But, RAN2 should check where the aspect that PDSCH(maybe CSI-RS)follow PDCCH TCI state is specified. Shall we add corresponding text e.g. in PDCCH MAC CEs or will this become clear in RRC or L1 specification?  BM had interesting approach to power control according to RAN1 parameter excel but that seems quite open still. If there is unified configuration of different UL channels for BM Rel-17 then new MAC CE is needed for power control. How this MAC CE will look would depend a lot on how unified the PC configuration would look like and which aspects the MAC CE control. E.g. only pathloss reference RS or compbination of parameters and the RS. |
| Qualcomm | Unified TCI state update MAC CE. Should we discuss it here? |
| Samsung | RAN1 have not fully concluded for the issues on the unified TCI framework and inter cell BM, so RAN2 need to further check other MAC CE impacts are required. |
| OPPO | We think it is premature to conclude that nothing more is needed. For example MAC CE to activate or deactivate unified TCI state is needed for both PDSCH and PDCCH for inter-cell beam management. In case same TCI state structure is shared between inter-cell BM and mTRP, it could be also applied for inter-cell mTRP. |
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**Rapporteur summary**

**TBD**

# Conclusion

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# Reference

1. RP-202024 Revised WID: Further enhancements on MIMO for NR, Samsung.
2. R2-2111214 LS Reply on inter-cell beam management and multi-TRP in Rel-17 (R1-2108717; contact: Nokia) RAN1 LS in Rel-17 NR\_feMIMO-Core To:RAN2 Cc: RAN4
3. R2-2109326 LS on Rel-17 inter-cell multi TRP (R1-2108633; contact: vivo) RAN1 LS in Rel-17 NR\_feMIMO-Core To:RAN2
4. R2-2110962 UL MAC CE enhancements for multi-TRP Samsung discussion Rel-17 NR\_feMIMO-Core.
5. R2-2110035 User plane impact of inter-cell beam management Apple discussion Rel-17 NR\_feMIMO-Core.
6. R2-2110341 On Rel-17 FeMIMO Ericsson Rel-17 NR\_feMIMO-Core.