**3GPP TSG RAN WG1 #100b R1-200xxxx**

**e-Meeting, April 20th – 30th, 2020**

**Agenda item:** 7.2.6.3.

**Source:** Moderator (LG Electronics)

**Title:** Summary of email thread [100b-e-NR-eMIMO-MB1-02]

**Document for:** Discussion and Decision

# Introduction

This contribution summaries discussion in email thread [100b-e-NR-eMIMO-MB1-02]

# Background and Summary of Proposals

In RAN1#100e, for the feature of MAC-CE based PL RS update, the UE behavior on tracking PL RS was agreed with regards to following aspects

* which RSs UE should track for pathloss estimation
* from when the updated RS by MAC-CE needs to be applied

When default PL RS is enabled, there are two cases:

* Case1: the QCL type-D RS of the lowest ID CORESET is used as the default PL RS
* Case2: the QCL type-D RS of the lowest ID TCI state among the activated TCI states for PDSCH

In Case1, N TCI states can be configured for the lowest ID CORESET by RRC (N≤64), and the TCI State Indication for UE-specific PDCCH MAC CE can select one of the N TCI states. In Case2, M TCI states can be activated by the TCI States Activation/Deactivation for UE-specific PDSCH MAC CE (M≤8) and TCI field in DCI can select one of the M TCI states. Therefore, the default TCI can be changed by the TCI State Indication for UE-specific PDCCH MAC CE in Case1 and by the TCI States Activation/Deactivation for UE-specific PDSCH MAC CE in Case2. Since both M and N are greater than 4, it needs to be clarified which RSs UE should track for pathloss estimation in the two cases. The application timing of the updated PL RS also needs to be clarified. When default PL RS is enabled for some UL channels and/or signals, there can be RRC configured PL RSs for other uplink channels/signals, e.g. for PUSCH0\_1. Therefore, it needs to be clarified on which RSs UE should track in this case as well, including whether the feature of MAC-CE based PL RS selection can still be enabled for other channels/signals.

9 tdocs submitted for these issues, which are Huawei/HiSilicon(Proposal2), ZTE(Proposal2), vivo(Proposal2), Sony(Proposal1), LGE(Proposal4/5), CMCC(Proposal5), Fraunhofer(Proposal4/5), NTT DOCOMO(Proposal2), Qualcomm(Proposal10).

NTT DOCOMO and vivo proposed that the delayed application timing defined for the newly activated PL RSs by MAC-CE needs to be applied when the default PL RS is changed by the TCI State Indication for UE-specific PDCCH MAC CE or the TCI States Activation/Deactivation for UE-specific PDSCH MAC CE. In ZTE’s tdoc, a problem of long-time mismatch between spatial relation/beam and PL RS was concerned when the delayed application timing is applied to default PL RS. An exemplary illustration is captured below from ZTE’s tdoc:



**Figure 1** Timeline misalignment between beam and path-loss RS update [R1-2001597]

To avoid the problem, ZTE proposed to track the additional PL RS(s) in addition to the RS corresponding to the CORESET with the lowest ID or active PDSCH-TCI state with the lowest ID. Similar technical observation can be found in Huawei/HiSilicon’s and LGE’s tdocs as well.

Qualcomm and Sony proposed to clarify that the feature of default PL RS can be enabled together with the feature of the MAC-CE based PL RS update. In order to reduce UE complexity, Huawei/HiSilicon proposed an additional condition that UE is not required to track RRC configured PL RSs for the UL channel/signal on which the default PL RS is not enabled when default PL RS is enabled. On the other hand, Qualcomm proposed that UE should track the other PL RSs as well as the default PL RS if the total number of configured PL RSs is not greater than 4. It needs to be noted that PL RSs can still be configured for PUSCH0\_1 even if default PL RS is enabled for all of PUSCH0\_0, PUCCH and SRS.

# Discussion

Based on the identified issues/alternatives summarized in section 2, companies are encouraged to provide their views on the following questions.

Q1: When the QCL type-D RS of the lowest ID CORESET is used as the default PL RS, which approach do you prefer?

* Alt1: UE is only required to track the QCL type-D RS of the lowest ID CORESET for pathloss estimation and the delayed application timing defined for the newly activated PL RSs by MAC-CE is applied when the QCL type-D RS is changed by the TCI State Indication for UE-specific PDCCH MAC CE.
* Alt2: The delayed application timing is not applied for the default PL RS and define additional RS(s) that needs to be tracked for pathloss estimation by UE in addition to the QCL type-D RS of the lowest ID CORESET.
  + FFS: which additional RS(s) UE needs to track (e.g. other TCIs for the lowest ID CORESET, the QCL type-D RS for other CORESET)
* Other alternative (please specify)

Q2: When the QCL type-D RS of the lowest ID TCI state among the activated TCI states for PDSCH is used as the default PL RS, which approach do you prefer?

* Alt1: UE is only required to track the lowest ID TCI state among the activated TCI states for PDSCH for pathloss estimation and the delayed application timing defined for the newly activated PL RSs by MAC-CE is applied when the QCL type-D RS is changed by the TCI States Activation/Deactivation for UE-specific PDSCH MAC CE
* Alt2: The delayed application timing is not applied for the default PL RS and UE is required to track the QCL type-D RS(s) in the activated TCI states by the TCI States Activation/Deactivation for UE-specific PDSCH MAC CE for pathloss estimation.
  + FFS: how to handle the case when more than 4 different QCL type-D RSs are activated for PDSCH by the MAC-CE
* Other alternative (please specify)

Q3: When the default PL RS is enabled for some or all of PUSCH0\_0, PUCCH and SRS, do you agree that UE should track RRC configured PL RSs for the UL channel/signal on which the default PL RS is not enabled in addition to the default PL RS if the total number of configured PL RSs is not greater than 4?

* Alt1: YES (please specify whether there is any spec impact)
* Alt2: NO (please specify whether there is any spec impact)

Q4: When the default PL RS is enabled for some or all of PUSCH0\_0, PUCCH and SRS, do you agree that gNB can still configure more than 4 PL RSs for the UL channel/signal on which the default PL RS is not enabled?

* Alt1: YES (please specify whether there is any spec impact)
* Alt2: NO (please specify whether there is any spec impact)

**Companies’ view (to be updated)**

|  |  |
| --- | --- |
| Company name | View |
| ZTE | Q1: Alt2.  Long-term misalignment between spatial relation/beam and path-loss RS in UL transmission as shown in Figure 1 occurs for each of beam switching through activating TCI state of PDCCH/CORESET with lowest ID, when there is only an active path loss RS to be tracked for the default beam and path loss mode. When the closed loop of UL transmission is accumulated and compensated based on the misaligned path-loss RS, some serious fluctuation of UL transmission/reception power may be experienced frequently. Consequently, The UE shall track additional RS, since the maximum number of PL RS to be tracked by UE is up to 4.  Q2: Alt2  The UE shall track additional RS, e.g., the QCL type-D RS for other TCI states. The same reason as in Q1 should be considered.  Q3: Alt1: Yes (No further spec impact is needed)  If the total number of RRC configured PL RS and default path loss RS is NOT beyond UE capability, the RRC configured PL RS should be tracked as agreed in last meeting.  Q4: Alt1: Yes (with spec impact. The rules of determining PL RS to be tracked in such case should be specified)  These two approaches should be decoupled, and the number of PL RSs can be configured with either more than or no more than 4, regardless of whether the default PL RS is enabled. If the total number of RRC configured PL RS and default path loss RS is beyond UE capability, a priority rule, e.g., default PL RS > RRC configured PL RS, should be considered.  Alternatively, we can consider the improvement of default PL RS determination for PUSCH scheduled by DCI format 0\_1 in order to avoid this combination case between default beam and path-loss approach and MAC-CE based path-loss update approach. |
| Ericsson | Q1: Alt2. Additional RSs to track are up to UE implementation, if more than 4 RSs are configured in total. Q2: Alt2. Additional RSs to track are up to UE implementation, if more than 4 RSs are configured in total. Q3: Yes. No spec impact Q4: Yes. The selection on which RSs to track is up to UE implementation, i.e., no spec impact. |
| Samsung | Q1: Support Alt. 2. Regarding FFS, we believe that it should be up to UE implementation and gNB has the responsibility for the cases when the corresponding TCI state indication is too much frequent to secure the measurement accuracy at UE side. Therefore, no new selection rule is required.  Q2: Support Alt. 2. Regarding FFS, we believe that it should be up to UE implementation and gNB has the responsibility for the cases when the corresponding TCI state indication is too much frequent to secure the measurement accuracy at UE side. Therefore, no new selection rule is required.  Q3: We think UE can track all PL RSs when the total number of default PL RSs, the configured Rel-15 PL RSs, and the activated Rel-16 PL RSs is less than 4. Otherwise, it should be UE implementation to track a part of the configured and/or activated PL RSs.  Q4: We think UE can track all PL RSs when the total number of default PL RSs, the configured Rel-15 PL RSs, and the activated Rel-16 PL RSs is less than 4. Otherwise, it should be UE implementation to track a part of the configured and/or activated PL RSs. |
| Nokia/NSB | Q1: Support Alt. 1 for simplicity. With Alt.2, when multiple of PL-RSs are configured or decided to be tracked as ‘additional’ RS of default PL-RS, it is unclear what would be UE’s operation when both default PL-RS and MAC-CE update of PL-RS are enabled. Considering timeline of Rel-16, we prefer only one RS to be selected as default PL-RS at any time, and let UE follow gNB’s configuration for other PL-RSs.  Q2: Support Alt. 1, as the same reason above. In mode details, if we support Alt. 2, then we should define separated operation for the following cases:   * Case 1: only default PL-RS is enabled * Case 2: only MAC CE update of PL-RS is enabled * Case 3: Both default PL-RS and MAC CE update of PL-RS are enabled.   We are also open to have discussion that Case 3 is not supported by the specification, but additional agreement should be made.  Q3: Alt. 1. Only editorial change will be needed.  Q3: Alt. 1. Only editorial change will be needed. |
| Apple | Q1: Alt3. Unified action time is defined for both beam indication and pathloss RS, which is 3ms delay. Before filtered RSRP is achieved, UE is allowed to apply L1-RSRP for power control during the transition period.  Q2: Alt3. Solution is the same as Q1.  We think Q3 and Q4 have been handled by the definition that UE is only required to maintain up to 4 pathloss RS. So for Q3, our understanding is Yes, and for Q4, it should be no. |
| OPPO | Q1: Alt1  Q2: Alt2  Q3 and Q4: the question is not clear. Our understanding is the pathloss RSs that a UE shall track includes the (1) the pathloss RS activated by MAC CE (2) RRC configured to one PUCCH/SRS or pathloss RS associated with SRI (3) pathloss RS the UE derive based “default pathloss RS”. And the total number of those pathloss RS shall be upper bounded by 4. |
| DOCOMO | Q1: Alt2. Additional RSs to track are up to UE implementation, if more than 4 RSs are configured in total. Q2: Alt2. Additional RSs to track are up to UE implementation, if more than 4 RSs are configured in total. Q3: Yes. No spec impact Q4: Yes. No spec impact, i.e. the selection on which RSs to track is up to UE implementation, if UE is configured more than 4 PL-RSs. |
| MediaTek | Q1, Q2: Support Alt1, For Alt2, it unnecessarily increases the UE complexity.  Q3, Q4: Alt1, there is no spec impact. |
| vivo | Q1: Alt1; Whether to capture timing is up to MB1\_01 discussion.  Q2: Alt1; Whether to capture timing is up to MB1\_01 discussion.  Q3 and Q4 are strongly coupled. It does not need further optimization at this late stage for the scenario that UE is configured with more than 4 PLRS but default beam is enabled. |
| CMCC | Q1, Q2: Alt1. It is up to gNB scheduling implementation to avoid the mismatch or up to UE implementation during the mismatch time.  Q3: Alt1: Yes. If the total number of RRC configured PL RS and default PL RS is not greater than 4, the RRC configured PL RS should be tracked.  Q4: Alt1: Yes. When the default PL RS is enabled, gNB can still configure more than 4 PL RSs. For example, although the default PL RS for SRS is enabled with the precondition that UE is not provided *pathlossReferenceRS* or *SRS-PathlossReferenceRS*, the RRC configured PL RS for PUCCH and PUSCH may be already greater than 4. If the total number of RRC configured PL RS and default PL RS is greater than 4, the PL RS to be tracked by UE should be further clarified. From our perspective, the three kinds of PL RS should be tracked by UE: 1) the PL RS activated by MAC CE, 2) the PL RS configured by RRC that are not related to MAC CE, 3) the default PL RS. |
| LGE | Q1: Support Alt2 to avoid timing misalignment issue. For FFS to track which additional RSs, it seems a reasonable option to track some or all of the RRC configured TCI states of the lowest ID CORESET.  Q2: Support Alt2. For FFS, the UE tracks all QCL Type-D RSs activated for PDSCH.  Q3: Yes. There is no spec. impact.  Q4: Yes. No spec change seems needed due to the yellow highlighted part of TP#2 for [100b-e-NR-eMIMO-MB1-01]: “If the number of RS resources configured by RRC for pathloss estimation for PUCCH, PUSCH and SRS is greater than 4, UE is not required to track the RS resources which are not activated by MAC-CE for the uplink channels and signals where the MAC-CE based activation of the RS resources for pathloss estimation is applicable as described in Clause 7.1.1, 7.2.1 and 7.3.1.” |
| Sony | Both Q1 and Q2: Alt.1. Firstly, the default PL RS follows either QCL-TypeD RS of CORESET or active TCI-state in *PDSCH-Config* (with lowest ID) which might be changed by MAC CE sooner or later. In such case, if we define another default PL RS, then the original default PL RS doesn’t make too much sense. Secondly, from the perspective of standard impact, we would like to support Alt.1 since we already specified default PL RS and MAC CE activated PL RS application timing.  Q3: Yes. Agree with CMCC, if the total # of configured PL RS is not greater than 4, then the UE should track the configured PL RS.  Q4: Yes. No matter default PL RS is enabled or disabled, the maximum # of configured PL RS is 64 if remember correctly and it is not necessary to put limitation on NW’s configuration. |
| CATT | Q1: Alt-2. Selection of additional RS for pathloss estimation is left to UE implementation.  Q2: Alt-2. How to handle more than four configured pathloss estimation RS is left to UE implementation.  Q3: Alt-1. No spec impact, handling is left to UE implementation.  Q4: Alt-1. No spec impact, handling is left to UE implementation. |
| Fraunhofer | Q1, Q2: Support Alt 1 as it would be a simpler solution (take MB1-01 outcome).  Q3, Q4: Alt-1. Tracking RRC configured PL RSs for the UL channel/signal on which the default PL RS is not enabled can be left to UE implementation, i.e., no spec impact. |
| Qualcomm | Q1: Alt.1. Prefer a simple/consistent UE behavior  Q2: Alt.1. Prefer a simple/consistent UE behavior  Q3: Alt.2. UE should only track activated PL RS regardless # of configured PL RS to simplify the behavior  Q4: Alt1. gNB can still configure more than 4 PL RS if MAC-CE based PL RS update is enabled. But total activated plus default PL RS should be no more than 4 |
| Huawei, HiSilicon | Q1: Alt1 for simplicity, prefer not to leave to UE implementation. Q2: Alt1 for simplicity, prefer not to leave to UE implementation.  Q3: In principle, we are in favor of Alt2. If time allows, we suggest grouping possible configurations and determine UE behaviors accordingly.  Q4: Alt1. |
| Lenovo/MOT | Q1: Alt 1 for simplicity and the timing misalignment can be avoid by NW implementation.  Q2: Alt 1 for simplicity and the timing misalignment can be avoid by NW implementation.  Q3: Alt1. There is no spec impact.  Q4: Alt1. The UE only required to track the activated PL-RS not all the configured PL-RS, so gNB can configured more than 4 PL-RSs if MAC CE based PL-RS update is enabled. |

Companies’ inputs are summarized as below:

For Q1,

* Alt1 is supported by 10 companies (Nokia/NSB, OPPO, MediaTek, vivo, CMCC, Sony, Fraunhofer, Qualcomm, Huawei/HiSilicon, Lenovo/MOT)
* Alt2 is supported by 6 companies (ZTE, Ericsson, Samsung, DOCOMO, LGE, CATT)
* New Alt from Apple: Unified action time is defined for both beam indication and pathloss RS, which is 3ms delay.

For Q2,

* Alt1 is supported by 9 companies (Nokia/NSB, MediaTek, vivo, CMCC, Sony, Fraunhofer, Qualcomm, Huawei/HiSilicon, Lenovo/MOT)
* Alt2 is supported by 7 companies (ZTE, Ericsson, Samsung, OPPO, DOCOMO, LGE, CATT)
* New Alt from Apple: Unified action time is defined for both beam indication and pathloss RS, which is 3ms delay.

For Q1 and Q2, the number of supporters of Alt1 is higher than Alt2. For Alt2, it also needs to be clarified whether the selection of RS(s) that UE should track can be left to UE implementation or not. Given the situation, it would be cleaner if we go with Alt1.

For Q3 and Q4, most companies’ answers were Alt1, which means that it is preferred to decouple these two features, i.e., the default PL RS and the MAC-CE based PL RS activation. In addition, some companies proposed to clarify that which PL RSs UE should track in this case, which will be helpful to align our understanding.

FL’s suggestion: For Q1/Q2, support Alt1.

* When the QCL type-D RS of the lowest ID CORESET is used as the default PL RS, UE is only required to track the QCL type-D RS of the lowest ID CORESET for pathloss estimation and the delayed application timing defined for the newly activated PL RSs by MAC-CE is applied when the QCL type-D RS is changed by the TCI State Indication for UE-specific PDCCH MAC CE.
* When the QCL type-D RS of the lowest ID TCI state among the activated TCI states for PDSCH is used as the default PL RS, UE is only required to track the lowest ID TCI state among the activated TCI states for PDSCH for pathloss estimation and the delayed application timing defined for the newly activated PL RSs by MAC-CE is applied when the QCL type-D RS is changed by the TCI States Activation/Deactivation for UE-specific PDSCH MAC CE.

FL’s suggestion: For Q3/Q4, support Alt1. Discuss on the possible agreement or conclusion for Q3/Q4 based on the following:

* If the total number of RRC configured PL RSs plus the RS(s) to be tracked for default PL RS is not greater than 4, all the RSs should be tracked.
* If the total number of RRC configured PL RS plus the RS(s) to be tracked for default PL RS is greater than 4, following PL RSs should be tracked.
  + the PL RS(s) activated by MAC CE for the UL channels/signals to which the MAC-CE based PL RS activation is applicable (if enabled)
  + the PL RS(s) configured by RRC for the UL channels/signals to which the MAC-CE based PL RS activation is not applicable, for example, configured grant PUSCH, periodic SRS.
  + the RS(s) to be tracked for default PL RS (if enabled)
* Note: ‘the RS(s) to be tracked for default PL RS’ can be further clarified based on the outcome of Q1/Q2

# Conclusion [to be updated]

From the email discussion [100b-e-NR-eMIMO-MB1-02], xxx

# References

|  |  |  |
| --- | --- | --- |
| **TDoc** | **Title** | **Source** |
| [**R1-2001564**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2001564.zip) | Remaining issues on multi-beam enhancements in R16 | Huawei, HiSilicon |
| [**R1-2001597**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2001597.zip) | Maintenance of multi-beam operation | ZTE |
| [**R1-2001679**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2001679.zip) | Discussion on remaining issues on multi beam operation | vivo |
| [**R1-2001818**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2001818.zip) | Remaining issues on multi-beam operation | Sony |
| [**R1-2001914**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2001914.zip) | Remaining issues on multi beam operation | LG Electronics |
| [**R1-2002213**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2002213.zip) | Remaining issues on multi-beam operation | CMCC |
| [**R1-2002283**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2002283.zip) | Enhancements on multi-beam operation | Fraunhofer IIS, Fraunhofer HHI |
| [**R1-2002449**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2002449.zip) | Remaining issues on multi-beam operation | NTT DOCOMO, INC |
| [**R1-2002552**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_100b_e/Docs/R1-2002552.zip) | Enhancements on Multi-beam Operation | Qualcomm Incorporated |