**3GPP TSG RAN WG1 #104b-e R1-2103953**

**e-Meeting, April 12th – 20th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#5 for multi-beam enhancement: Round 4

**Document for:** Discussion and Decision

## Summary of companies’ inputs

### Issue 1 (Rel.17 unified TCI framework for intra-cell beam management)

Table 1 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** |
| 1.6 | Setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index): In addition to association with UL channel/RS,   * Alt1. The setting of (P0, alpha, closed loop index) is also associated with UL or (if applicable) joint TCI state * Alt2. The setting of (P0, alpha, closed loop index) is included with UL or (if applicable) joint TCI state * Alt3. The setting of (P0, alpha, closed loop index) is neither associated with nor included in UL or (if applicable) joint TCI state * Alt4. The setting of (P0, alpha, closed loop index) is determined as in Rel-16 without enhancement | **Alt1 (11)**: Lenovo, CMCC (PUCCH), Nokia/NSB, NTT Docomo, Spreadtrum, CATT, ZTE, OPPO (PUSCH, PUCCH), Qualcomm, Futurewei  **Alt2 (6)**: IDC, Samsung, Intel (at least PUCCH), Apple, Qualcomm, LGE  **Alt3 (5)**: Fraunhofer IIS/HHI, CMCC (PUSCH – SRI, SRS – SRSResourceSet), Ericsson (for P0 and alpha), Sony,  **Alt4 (5)**: vivo, OPPO (SRS), MTK, Huawei, HiSi |
| 1.7 | Path-loss measurement (PL RS):   * Alt1. PL-RS can be included in UL TCI state or (if applicable) joint TCI state.   + FFS: Whether it is always included or not. If not included, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state. * Alt2. PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state   + FFS: Exact association mechanism   + FFS: Whether it is always associated or not. If not associated, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter or the PL RS used for the UL RS in UL or (if applicable) joint TCI state * Alt3. The periodic DL-RS used as a source RS for determining spatial TX filter can be used as PL-RS. In case the periodic DL-RS used as a source RS for determining spatial TX filter is not used as PL-RS, reuse Rel.16 procedure with the same signaling structure (MAC CE+SRI field in UL-related DCI) to indicate PL-RS for UL transmission with minimum enhancement (e.g. pertaining to the use for PUCCH, or using default PL-RS)   + PL-RS is not additionally configured in or associated to UL TCI state or (if applicable) joint TCI state * Alt4. UE calculates path-loss based on periodic DL RS configured as the source RS or a periodic QCL-Type-D/spatialRelationInfo source of the source RS in UL TCI state or (if applicable) joint TCI state   + FFS: Whether UE can calculate path-loss based on DL periodic RS for path-loss calculation for UL RS in the UL TCI | **Alt1 (10)**: IDC, Fraunhofer IIS/HHI, Ericsson (if UL RS in TCI state), NTT Docomo, OPPO, Intel (at least PUCCH), Qualcomm, AT&T, LGE  **Alt2 (14)**: Lenovo/MoM, CMCC, NTT Docomo, Huawei, HiSi, Spreadtrum, CATT, ZTE, MTK, Futurewei, Sony, Nokia/NSB  **Alt3 (1)**: vivo  **Alt4 (3)**: Ericsson (if DL RS in TCI state), Samsung, Apple, |

**Table 2: PL-RS**

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| **(New) Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#105-e, further discuss to down select or combine from the following two alternatives for PL-RS (note: the text below is based on the agreed description in RAN1#104-e):   * Alt1. PL-RS is included in UL TCI state (or, if applicable, joint TCI state). * Alt2. PL-RS is associated with (but not included in) UL TCI state (or, if applicable, joint TCI state)   + FFS: Exact association mechanism   In addition:   * Support a UE reporting its capability of whether it supports the periodic PL-RS included in or associated with an UL TCI state (or, if applicable, joint TCI state) being the same as TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state).   + [Beam alignment indicates that the total number of TCI/spatialRelation for the PL-RS and the RS in UL TCI (or, if applicable, joint TCI) should be counted as 1 based on the principle defined in UE FG 2-62.] * For the case when periodic DL RS is configured as the source RS in UL or joint TCI state, the UE estimates path-loss based on the periodic DL-RS provided as a source RS for determining spatial TX filter in UL or (if applicable) joint TCI state   + FFS: If a PL RS is not included in or associated with the UL TCI state (or, if applicable, joint TCI state), whether the UE can estimate path-loss based on the PL-RS of an UL RS provided in an UL TCI state (or, if applicable, joint TCI state) as a source RS for determining the spatial TX filter. * [Support additional UE capability to report whether above PLRS determination mechanism is supported.] * FFS whether/when a fallback scheme is needed and, if so, further details * Note: As agreed in RAN1#104-e, the total number of maintained PL-RSs per CC is no more than 4   + FFS: investigate the condition(s) agreed in Rel-17 and, if needed, study whether a UE can simultaneously maintain more than four path-loss estimates based on UE capability   + FFS: UE capability for maximum number of active PL-RS across CCs per band |

**Table 3**

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| Mod V00 | Proposal 1.5: Based on previous discussion and some offline discussion I was informed of, the new proposal 1.5 could be a good starting point. It basically builds on the format for the previous 1.5B (from Futurewei) but including some parts from 1.5A without agreeing on a default scheme but with addressing concern from some companies about misalignment between PL-RS and   * **Please share your view** * **Since PL-RS has been discussed since day-1 please be flexible when it comes to less essential (purely style or flavor preference) matters** |
| **Company** | **Input** |
| CATT | Support the proposal. |
| vivo | With the following as our preference:  (**New) Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#105-e, further discuss to down select or combine from the following two alternatives for PL-RS (note: the text below is based on the agreed description in RAN1#104-e):   * Alt1. PL-RS is included in UL TCI state (or, if applicable, joint TCI state). * Alt2. PL-RS is associated with (but not included in) UL TCI state (or, if applicable, joint TCI state)   + FFS: Exact association mechanism   In addition:   * Support a UE reporting its capability of whether it expects beam alignment between the PL-RS included in or associated with an UL TCI state (or, if applicable, joint TCI state) and the TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state).   + Beam alignment indicates that the total number of TCI/spatialRelation for the PL-RS and the RS in UL TCI (or, if applicable, joint TCI) should be counted as 1 based on the principle defined in UE FG 2-62. * For the case when periodic DL RS is configured as the source RS in UL or joint TCI state, the UE estimates path-loss based on the periodic DL-RS provided as a source RS for determining spatial TX filter in UL or (if applicable) joint TCI state * ~~Depending on the final outcome, FFS on exact association mechanism and whether to support a unified mechanism for the setting of (P0, alpha, closed loop index) and PL-RS, if PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state~~ * Support additional UE capability to report whether above PLRS determination mechanism is supported. ~~FFS whether/when a fallback scheme is needed and, if so, further details~~ * FFS: The total number of maintained PL-RSs per CC * FFS: UE capability for maximum number of active PL-RS across CCs per band |
| OPPO | Support the 1.5 |
| Samsung | For progress we can accept this proposal 1.5. |
| MediaTek | Support 1.5 except the FFS for the number of PLRS maintained by UE. Why this issue is re-opened? In previous meeting, it was agreed that at most four PLRSs are maintained by UE simultaneously per CC. If more PLRSs are needed, the use case should be agreed first. We suggest either removing the FFS, or putting the following paragraph agreed by RAN1 in the proposal.   * *NOTE: As in Rel-16, a UE does not expect to simultaneously maintain more than four path-loss estimates per serving cell for all PUSCH/PUCCH/SRS transmissions*    + *FFS: investigate the condition(s) agreed in Rel-17 and, if needed, study whether a UE can simultaneously maintain more than four path-loss estimates* |
| LG | Support the proposal.  To address the MTK’s concern, the suggested modification seems also OK as Futurewei mentioned in email discussion in the following:   * The total maintained PL RS # per CC is no more than 4   + FFS: investigate the condition(s) agreed in Rel-17 and, if needed, study whether a UE can simultaneously maintain more than four path-loss estimates based on UE capability |
| Spreadtrum | Support the proposal. We have similar view as MediaTek, and suggest either remove the FFS or replace it by the Note. |
| ZTE | In our views, we may not need to introduce a new definition of beam alignment, and suggest to clarify it based on RAN1 spec description, like: the PL-RS is the same as TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state). If so, we think that counting RS is clear for FG 2-62. Besides, ‘is’ is too strong, and let’s use ‘can be’.  In addition:   * Support a UE reporting its capability of whether it expects the periodic PL-RS included in or associated with an UL TCI state (or, if applicable, joint TCI state) is the same as TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state). * Depending on the final outcome, FFS on exact association mechanism and whether to support a unified mechanism for the setting of (P0, alpha, closed loop index) and PL-RS, if PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state * FFS whether/when a fallback scheme is needed and, if so, further details * FFS: The total number of maintained PL-RSs per CC * FFS: UE capability for maximum number of active PL-RS across CCs per band |
| Nokia | Generally O.K. with the proposal, but small concerns on the exact meaning of "ability of whether it expects beam alignment”., since expectation could not be a UE capability:  Support a UE reporting its capability of whether it supports ~~expects~~ beam alignment between the PL-RS included in or associated with an UL TCI state (or, if applicable, joint TCI state) and the TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state). |
| Ericsson | Do not support. We do not see that this adds anything to the agreement from 104e – the only addition is the UE capability, which would be a later issue in any case.  We would be supportive of the direction of the vivo proposal, which is very much in line with the common beam operation that we are targeting. However, we cannot have that all possibilities to determine PLRS are optional – there has to be one mode of operation that all UEs can support – we simply have to describe what that mode of operation is.  To us it is difficult to understand why we cannot at least agree that a periodic DL RS is configured as the source RS in UL or joint TCI state can be used as PL RS – as a default. This does not rule out the use of aperiodic RSs in TCI states, it is simply a separate issue. |
| Frauhofer IIS/HHI | We support ZTE’s proposal regarding the inclusion or the association – it need not be always included or associated. Mandating it is stricter and unnecessary overhead. To account for the cases when PL-RS is not explicitly configured, the previously agreed “default” behavior can be included with a condition “if a PL RS is not included in or associated with the UL TCI state”. This could be the scheme for beam alignment or overhead reduction. We would also suggest to include the FFS from the previous version regarding the PL RS of the UL-RS as a sub-bullet to this.  We also suggest the revise the beam-alignment sub-bullet along what ZTE has proposed.  Finally, we are ok with having an FFS on the decision of a scheme when Alt. 1 and Alt. 2 are not supported. We suggest to clarify the FFS accordingly. We are ok with the FFS for the total number of PL RSs maintained per CC.  **Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#105-e, further discuss to down select or combine from the following two alternatives for PL-RS (note: the text below is based on the agreed description in RAN1#104-e):   * Alt1. PL-RS ~~is~~ can be included in UL TCI state (or, if applicable, joint TCI state). * Alt2. PL-RS ~~is~~ can be associated with (but not included in) UL TCI state (or, if applicable, joint TCI state)   + FFS: Exact association mechanism   In addition:   * Support a UE reporting its capability of whether it expects a periodic DL RS provided in an UL TCI state (or, if applicable, joint TCI state) as source RS for determining the spatial TX filter is the same as the PL RS included in or associated with the UL/joint TCI state. * For the case when periodic DL RS is configured as the source RS in UL TCI state (or, if applicable, joint TCI state) for determining the spatial TX filter, and a PL RS is not included in or associated with the UL TCI state (or, if applicable, joint TCI state), the UE estimates path-loss based on the periodic DL-RS.   + FFS: If a PL RS is not included in or associated with the UL TCI state (or, if applicable, joint TCI state), whether the UE can estimate path-loss based on the PL-RS of an UL RS provided in an UL TCI state (or, if applicable, joint TCI state) as a source RS for determining the spatial TX filter. * Depending on the final outcome, FFS on exact association mechanism and whether to support a unified mechanism for the setting of (P0, alpha, closed loop index) and PL-RS, if PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state * FFS whether/when a fallback scheme is needed when neither Alt. 1 nor Alt. 2 is supported. If so, further details. * FFS: The total number of maintained PL-RSs per CC * FFS: UE capability for maximum number of active PL-RS across CCs per band |
| Mod V16 | Revised proposal 1.5 based on all the inputs. Main changes: largely based on vivo, MTK, and ZTE inputs, but the additional UE capability bullet is between brackets. I hope this partially resolves the concern from Ericsson. Also added the FFS bullet from Fraunhofer.  I urge the group to be flexible here. It seems no matter what direction we take someone has an issue. If your view is not strong and based on implementation concern, please be flexible. |
| Futurewei | We are mostly ok with the proposal except the newly added bullet on beam alignment. We do not recall there were any discussion or agreement on beam alignment in Rel-17. More discussion is needed so let’s put it as FFS. It is also helpful that the group have a common understanding of beam alignment before further discussion on this. We also agree with MediaTek and LG to maintain the PL RS # per CC up to 4 (as in R16) and then add an FFS.  **(New) Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#105-e, further discuss to down select or combine from the following two alternatives for PL-RS (note: the text below is based on the agreed description in RAN1#104-e):   * Alt1. PL-RS is included in UL TCI state (or, if applicable, joint TCI state). * Alt2. PL-RS is associated with (but not included in) UL TCI state (or, if applicable, joint TCI state)   + FFS: Exact association mechanism   In addition:   * FFS: Support a UE reporting its capability of whether it expects beam alignment between the PL-RS included in or associated with an UL TCI state (or, if applicable, joint TCI state) and the TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state).   + ~~Beam alignment indicates that the total number of TCI/spatialRelation for the PL-RS and the RS in UL TCI (or, if applicable, joint TCI) should be counted as 1 based on the principle defined in UE FG 2-62.~~ * Depending on the final outcome, FFS on exact association mechanism and whether to support a unified mechanism for the setting of (P0, alpha, closed loop index) and PL-RS, if PL-RS can be associated with (but not included in) UL TCI state or (if applicable) joint TCI state * FFS whether/when a fallback scheme is needed and, if so, further details * The total maintained PL RS # per CC is no more than 4   + FFS: investigate the condition(s) agreed in Rel-17 and, if needed, study whether a UE can simultaneously maintain more than four path-loss estimates based on UE capability * FFS: UE capability for maximum number of active PL-RS across CCs per band |
| Lenovo/MoM | We are mostly ok with the proposal. But we think this FFS   * + FFS: If a PL RS is not included in or associated with the UL TCI state (or, if applicable, joint TCI state), whether the UE can estimate path-loss based on the PL-RS of an UL RS provided in an UL TCI state (or, if applicable, joint TCI state) as a source RS for determining the spatial TX filter.   falls into the fallback scheme, which is addressed by the next FFS (whether/when a fallback scheme is needed and, if so, further details). The first FFS should be made part the second FFS.  Our proposal is to combine the two FFS as below:   * FFS whether/when a fallback scheme is needed (for example, when a PL RS is not included in or associated with the UL TCI state (or, if applicable, joint TCI state)), if so, further details. |
| Samsung2 | For progress we support the latest feature lead proposal.  We prefer not to keep the bullet on additional UE capability. The unified TCI framework is an optional feature. If supported, we would like the agreed PLRS scheme to be a basic sub-feature. It creates additional complexity to support multiple schemes for the same feature. |
| Qualcomm | First, we prefer not to tie the proposal of using periodic source RS to Alt1 or 2. Otherwise, for UE preferring to use periodic source RS, it has to support either Alt1 or 2. Suggest to make this option as a standalone option with UE capability. Also for UE supporting this option, UE should also be able to report whether supporting the source RS to be non-periodic RS.  Second, the 2nd bullet under in addition should be removed. Because it is already mentioned below that default scheme for Alt1/2 is FFS. So the 2nd bullet should belong to that FFS.  In short, we prefer UE can choose Alt1/2, or using periodic source RS. They ideally should be independent options without multiple modes per option.  **(New) Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#105-e, further discuss to down select or combine from the following two alternatives for PL-RS (note: the text below is based on the agreed description in RAN1#104-e):   * Alt1. PL-RS is included in UL TCI state (or, if applicable, joint TCI state). * Alt2. PL-RS is associated with (but not included in) UL TCI state (or, if applicable, joint TCI state)   + FFS: Exact association mechanism   In addition:   * Support a UE reporting its capability of whether it supports the periodic PL-RS included in or associated with an UL TCI state (or, if applicable, joint TCI state) being the same as TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state).   + [Beam alignment indicates that the total number of TCI/spatialRelation for the PL-RS and the RS in UL TCI (or, if applicable, joint TCI) should be counted as 1 based on the principle defined in UE FG 2-62.]   + If UE indicates the support of using periodic Tx spatial source RS as PL RS, UE can further indicate whether supporting the source RS to be non-periodic RS     - If not supporting, UE expects that the TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state) is period RS. * ~~For the case when periodic DL RS is configured as the source RS in UL or joint TCI state, the UE estimates path-loss based on the periodic DL-RS provided as a source RS for determining spatial TX filter in UL or (if applicable) joint TCI state~~   + ~~FFS: If a PL RS is not included in or associated with the UL TCI state (or, if applicable, joint TCI state), whether the UE can estimate path-loss based on the PL-RS of an UL RS provided in an UL TCI state (or, if applicable, joint TCI state) as a source RS for determining the spatial TX filter.~~ * [Support additional UE capability to report whether above PLRS determination mechanism is supported.] * FFS whether/when a fallback scheme is needed and, if so, further details * Note: As agreed in RAN1#104-e, the total number of maintained PL-RSs per CC is no more than 4   + FFS: investigate the condition(s) agreed in Rel-17 and, if needed, study whether a UE can simultaneously maintain more than four path-loss estimates based on UE capability   + FFS: UE capability for maximum number of active PL-RS across CCs per band |
| OPPO | We are not sure if the first bullet under “In addition” is correct or not:   * Support a UE reporting its capability of whether it supports the periodic PL-RS included in or associated with an UL TCI state (or, if applicable, joint TCI state) being the same as TX spatial source RS of the UL TCI state (or, if applicable, joint TCI state).   + [Beam alignment indicates that the total number of TCI/spatialRelation for the PL-RS and the RS in UL TCI (or, if applicable, joint TCI) should be counted as 1 based on the principle defined in UE FG 2-62.]   From our view, the original intention of this bullet is to avoid beam misalignment of PL RS and RS for Tx spatial resource RS. But the current wording says those two RS shall be same. Then what about the case when SRS is used as Tx spatial source RS? We think the original wording is better to explain our intention here even through it is hard to capture “beam alignment” in spec. |
| ZTE2 | We do understand the motivation of QC’s revision. But, after reviewing this revised version, the logic is a little bit confusing. Firstly, the UE indicate whether it can support the periodic PL-RS should be the same as TX spatial source RS; then, the UE indicate whether it can support aperiodic RS as Tx spatial source RS. It seems to cover all candidates, and if so, we may not need the first sub-bullet. If my understanding is correct, if the periodic DL RS is the source RS, we think that all UE can support that this RS can be used for PL RS, right? If so, we may do not need the first UE capability.  To simplify this proposal and also considering the concerns from other companies, like E/// and OPPO. We suggest to have the following update on top of FL proposal.  In addition:   * For the case when periodic DL RS is configured as the source RS in UL or joint TCI state, and if PL-RS is neither included in nor associated with (but not included in) UL TCI state (or, if applicable, joint TCI state), the UE estimates path-loss based on the periodic DL-RS provided as a source RS for determining spatial TX filter in UL or (if applicable) joint TCI state   + When UE further indicates supporting the source RS to be non-periodic DL RS, and if non-periodic DL RS is configured as the source RS in UL or joint TCI state, the UE expects that PL-RS is included in or associated with (but not included in) UL TCI state (or, if applicable, joint TCI state).   + FFS: If a PL RS is not included in or associated with the UL TCI state (or, if applicable, joint TCI state), whether the UE can estimate path-loss based on the PL-RS of an UL RS provided in an UL TCI state (or, if applicable, joint TCI state) as a source RS for determining the spatial TX filter. * [Support additional UE capability to report whether above PLRS determination mechanism is supported.] * FFS whether/when a fallback scheme is needed and, if so, further details * Note: As agreed in RAN1#104-e, the total number of maintained PL-RSs per CC is no more than 4   + FFS: investigate the condition(s) agreed in Rel-17 and, if needed, study whether a UE can simultaneously maintain more than four path-loss estimates based on UE capability   + FFS: UE capability for maximum number of active PL-RS across CCs per band |

### Issue 2 (L1/L2-centric inter-cell mobility)

**Table 4**

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| **Proposal 2.1**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * In one reporting instance, depending on NW configuration, beam(s) associated with a non-serving cell can be mixed with that associated with serving-cell   + FFS: whether this applies to periodic, semi-persistent, and/or aperiodic   + FFS: How to report the K beams and corresponding qualities if the Tx power among the non-serving cell and with serving-cell is not the same   + Note: The supported numbers of non-serving cells (in terms of measurement/reporting) have not yet been decided. The above description doesn’t imply only one non-serving cell is allowed to be configured for measurement. Nor does this imply that only one non-serving cell is allowed in one reporting instance.   **Proposal (working assumption) 2.2**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * For L1-RSRP measurement and at least aperiodic reporting, depending on the supported value(s) of maximum K, support MAC CE based dynamic activation/deactivation of a subset of higher-layer-configured measurement for non-serving cell SSBs   + FFS: Additionally activated non-serving cell information for SSBs to be measured, or activated measurement resource configuration(s) of non-serving cell SSBs   + FFS: Dynamic (MAC CE and/or DCI) activation for measurement RS other than non-serving cell SSB, if supported   **Proposal 2.3**: Send LS to RAN4 to ask their views on DL measurement timing assumptions for L1/L2-centric inter-cell mobility and inter-cell mTRP. |

**Table 5**

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| Mod V00 | Proposal 2.1: A few companies argue that mixed SC/NSC report is mainly for aperiodic. Nokia argues that if mixed SC/NSC report is agreed, it should be for P, SP, and AP:   * **Please share your view on the cyan text above on supporting mixed report for P, SP, and AP**   Proposal 2.2: A few companies argue that MAC CE activation of SSBs can be instrumental if at least one maximum K is agreed to be large. But most companies support this feature at least for UE power saving.   * **Would a working assumption be acceptable, which can be confirmed if a large value of max K is supported?**   Proposal 2.3: After a proposal on timing assumption didn’t go through vivo proposed to send an LS to RAN4. **Please share your view on this** |
| **Company** | **Input** |
| CATT | Proposal 2.1: Support the cyan text. We believe this functionality should be supported in Rel.17.  Proposal 2.2: Support the proposal. A working assumption is acceptable.  Proposal 2.3: OK |
| vivo | Support all the three proposals. |
| OPPO | Proposal 2.1: regarding the cyan part, we prefer to agree AP first and FFS on SP and P.  Proposal 2.2 WA is ok  Proposal 2.3: support |
| Samsung | We suggest that proposal 2.1 only considers mixing SC and NSC reports in a single reporting instance, regardless of report type. FFS can be kept for report type  **Proposal 2.1**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * ~~For [periodic, semi-persistent, and aperiodic] reporting,~~ in one reporting instance, depending on NW configuration, beam(s) associated with a non-serving cell can be mixed with that associated with serving-cell   + FFS: whether this applies to periodic, ~~and~~ semi-persistent and aperiodic.   + FFS: How to report the K beams and corresponding qualities if the Tx power among the non-serving cell and with serving-cell is not the same   + Note: The supported numbers of non-serving cells (in terms of measurement/reporting) have not yet been decided. The above description doesn’t imply only one non-serving cell is allowed to be configured for measurement. Nor does this imply that only one non-serving cell is allowed in one reporting instance.   For proposal 2.2, not clear on the intention of “or activated non-serving cell SSBs” NSC SSBs are always transmitted, it is only the measurement reporting that can be activated or deactivated. Suggest to update as: “or ~~activated~~ non-serving cell SSBs”  Proposal 2.3: Support  In the previous rounds, even if there is a strong majority on supporting different timing assumptions between SC and NSC, an agreement could not be made. Perhaps some input from RAN4 can help to progress |
| MediaTek | P2.1: Okay to keep the cyan text, or put all of them for further study, as suggested by Samsung (FFS: Supported time behavior, periodic, semi-persistent, and/or aperiodic)  P2.2: Okay to keep it as WA. However, we would like to clarify the last FFS. Does it intend to study whether dynamic activation is needed for semi-persistent measurement? If so, since RAN1 only agrees NSC SSB for now, we see this study should be opened for measurement RS other than NSC SSB, if supported. Thus, we prefer to revise the FFS as :   * + FFS: Dynamic (MAC CE and/or DCI) activation for ~~semi-persistent~~ measurement RS other than non-serving cell SSB, if supported   P2.3: Okay |
| LG | On Proposal 2.1: We support the cyan text that can be incorporated in the existing CSI framework with NW-triggered reporting.  On Proposal 2.2: The motivation is still unclear to us. We don’t think that updating NSCell ID(s) for beam management is frequently required where one or two NSCell(s) would be considered for a cell-edge UE in general. Hence, it is sufficient to reuse the existing CSI framework. When beam quality of NCS is better than that of SC, gNB would most likely initiate HO to the NSC followed by the corresponding RRC reconfiguration of measurement RSs. If it is for aperiodic reporting, current spec allows selecting a resource set among multiple resource sets by DCI. Why do we need MAC-CE for aperiodic beam reporting? |
| Spreadtrum | Proposal 2.1: Support. We have a clarification issue, does this proposal mean non-serving cell RSRP cannot be reported without serving cell RSRP? If it’s not the case, we suggest to add a note:   * + Note: Depending on NW configuration, beam(s) associated with a non-serving cell can be separately reported.   Proposal 2.2: Fine. The confirmation should depend on the maximum # configured NSC RS supported in spec.  Proposal 2.3: OK. |
| ZTE | Proposal 2.1: We slightly prefer to keep the cyan text.  Proposal 2.2: Support. Regarding LG’s comments, we think that the motivation is how to enable UE measurement dynamically. For instance, for current aperiodic RS reporting + periodic RS as a typical case for NSC, the periodic RS should be mandatorily measured by the UE; otherwise, the UE do not have sufficient time of capturing all periodic RS, e.g., 64 SSBs. Thus we need to consider how to activate the RS measurement  Proposal 2.3: No strong preference, and we can live with either ways. |
| Xiaomi | For proposal 2.1, we are fine with the proposal. And we think for each reporting instance, there are 3 cases: only beam(s) associated with a serving cell, only beam(s) associated with a non-serving cell, or beam(s) associated with a serving cell and a non-serving cell.  For proposal 2.2, we can accept it when the value of max K is large.  For proposal 2.3, we support it. |
| Sony | P2.1, we think it’s not necessary to mix up with P/SP reporting.  Normally, NW configures a UE with P/SP beam reporting in its serving cell. But different from SC, due to its randomness, NSC beam reporting can be aperiodically carried out. The combination of SC and NSC beam measurement results is to let NW have a view on which cell is better to serve this UE.  P2.2, in our view, the condition should be if RRC configured K SSBs are too much for a UE to track and measure. |
| Nokia | Proposal 2.1 In principle we support mixing SC and NSC in the same report, no matter of the reporting type. So we are fine to have this for P/AP/SP. We can either agree on this this now, or as stated in some proposals above, take the P/AP/SP reporting into a next level of discussion. What we do not see necessarily now is decoupling the agreement between the three reporting types.  Proposal 2.2: Support in principle. the activation of measurement should be clarified i.e. activation of measurement resource configurations for non-serving cell SSBs. SSBs are always present but within the BM framework UE cannot report SSBs that are not configured as measurement resources.  **Proposal (working assumption) 2.2**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * For L1-RSRP measurement and at least aperiodic reporting, support MAC CE based dynamic activation/deactivation of a subset of higher-layer-configured measurement resource configurations for non-serving cell SSBs   + FFS: Additionally activated non-serving cell information for SSBs to be measured, or activated measurement resource configurations ofnon-serving cell SSBs   + FFS: Dynamic (MAC CE and/or DCI) activation for semi-persistent   Proposal 2.3 We would prefer to see the LS text before ageing to send it! It matter quite a bit on the level of how the questions are articulated. Hence, we do not agree to send an LS and work on the text after that. |
| Ericsson | P2.1: Support  P2.2: Do not support, not even as a WA, for the following reasons:   * For aperiodic reporting, we already have Aperiodic CSI Trigger State Subselection MAC CE – to us it would seem that this would do exactly this. * If is also not at all clear how this is related to K, since the number of SSBs the UE would have to measure is larger than K in any case: already in R15, the UE may have to measure up to 64 SSBs * The UE already today measures all 1000 PCI candidates for L3 mobility.   P2.3: We could be OK to send such an LS. Again note that the UE performs measurements on non-synchronized SSBs for all 1000 PCI candidates already today, so fundamentally this is not new. It could be that there are issues realted to side conditions for L1-RSRP measurement, so we would need to be precise when the LS is formulated. |
| Mod V16 | Revised proposals 2.1 and 2.2 based on the inputs.  Proposal 2.1: Given the comments, the discussion on the supported time behavior (P, SP, AP) will be done later.  Proposal 2.2: So far only Ericsson raised some concern. I added “depending on the supported value(s) of maximum K” which hopefully alleviates some of the concern.  Proposal 2.3: No company raised any concern. I will request an email discussion for this so that the group can formulate the LS carefully (cf. Ericsson’s input, very much true) |
| Futurewei | Proposal 2.1: Support.  Proposal 2.2: As commented by Ericsson, this feature might already be supported by existing MAC CE and we do not need to invent new tool to support the same feature. Suggest adding “FFS” in front of the whole bullet.  Proposal 2.3: Ok. |
| Lenovo/MoM | Proposal 2.1: Support  Proposal 2.2: We agree with Ericsson and Futurewei.  Proposal 2.3: Support |
| Samsung2 | Proposal 2.1 and 2.3 support  Proposal 2.2, we would like to keep the original second FFS. The main bullet deals with at least aperiodic reporting. The second FFS is for semi-persistent reporting.  **Proposal (working assumption) 2.2**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,   * For L1-RSRP measurement and at least aperiodic reporting, depending on the supported value(s) of maximum K, support MAC CE based dynamic activation/deactivation of a subset of higher-layer-configured measurement for non-serving cell SSBs   + FFS: Additionally activated non-serving cell information for SSBs to be measured, or activated measurement resource configuration(s) of non-serving cell SSBs   + FFS: Dynamic (MAC CE and/or DCI) activation for ~~measurement RS other than non-serving cell SSB, if supported~~ semi-persistent reporting |
| Qualcomm | We are fine for Proposal 2.1, 2.2, and 2.3. |
| OPPO | OK with the latest 2.1, 2.2 and 2.3 |
| ZTE2 | We can support Proposal 2.1~2.3 |

### Issue 3 (signaling medium)

**Table 6**

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| **Possible Agreement**  For beam indication with Rel-17 unified TCI, support DCI format 1\_1/1\_2 without DL assignment:   * Use ACK/NACK mechanism analogous to that for SPS PDSCH release with both type-1 and type-2 HARQ-ACK codebook:   + Upon a successful reception of the beam indication DCI, the UE reports an ACK     - Note that upon a failed reception of the beam indication DCI, a NACK can be reported.     - For type-1 HARQ-ACK codebook, a location for the ACK information in the HARQ-ACK codebook is determined based on a virtual PDSCH indicated by the TDRA field in the beam indication DCI, based on the time domain allocation list configured for PDSCH     - For type-2 HARQ-ACK codebook, a location for the ACK information in the HARQ-ACK codebook is determined according to the same rule for SPS release   + The ACK is reported in a PUCCH *k* slots after the end of the PDCCH reception where *k* is indicated by the PDSCH-to-HARQ\_feedback timing indicator field in the DCI format, or provided *dl-DataToUL-ACK* or *dl-DataToUL-ACK-ForDCI-Format1-2-r16* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the DCI * When used for beam indication:   + CS-RNTI is used to scramble the CRC for the DCI   + The values of the following DCI fields are set as follows:     - RV = all ‘1’s     - MCS = all ‘1’s     - NDI = 0     - Set to all ‘0’s for FDRA Type 0, or all ‘1’s for FDRA Type 1, or all ‘0’s for dynamicSwitch (same as in Table 10.2-4 of TS38.213)     - FFS: Whether HPN is also used * Use ~~at least~~ the existing TCI field (always present) to signal the following: 1) Joint DL/UL TCI state, 2) DL-only TCI state (for separate DL/UL TCI), 3) UL-only TCI state (for separate DL/UL TCI)   + FFS: Whether both DL TCI and UL TCI states can be signaled in one instance of beam indication DCI   + FFS: Relation with joint vs separate TCI (DL and/or UL) switching, including M/N>1 if supported * In addition, use ~~at least~~ the following DCI fields as the fields are being used in Rel-16:   + Identifier for DCI formats   + Carrier indicator   + Bandwidth part indicator   + TDRA   + Downlink assignment index (if configured)   + TPC command for scheduled PUCCH   + PUCCH resource indicator   + PDSCH-to-HARQ\_feedback timing indicator (if present) * The remaining unused DCI fields and codepoints are reserved in R17 * Support UE to report whether or not to support TCI update by DCI format 1\_1/1\_2.   + For a UE supporting TCI update by DCI format 1\_1/1\_2, it must support TCI update by using DCI 1\_1/1\_2 with DL assignment, and support of the above feature for TCI update by DCI format 1\_1/1\_2 without DL assignment is UE optional   + FFS: How to handle the case when there is UL data   + FFS: The case for UE being indicated with separate UL TCI in DCI format 1\_1/1\_2 with DL assignment0 * FFS: When more than one TCI codepoints are activated by MAC CE, the activated TCI state(s) for the lowest codepoint is/are applied   + Support of this feature is UE optional   + The “lowest codepoint” function can be configured on or off.   + FFS: Interaction with the DCI based beam update if needed, whether/how to support the case with M or N > 1 if supported * Note: This agreement on DCI beam indication design is not to be used to be against the support of the cases of M/N>1. The support of M/N>1 will be separately discussed and not dependent on the decision here. |

**Table 6B**

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| Mod V00 | Proposal 3.1: Based on offline discussions among those with strong views. This compromise has been acceptable. |
| **Company** | **Input** |
| Futurewei | Support the proposal. |
| Samsung2 | As a compromise, we can support proposal 3.1. |
| Qualcomm | Some minor wording clarification if that is the intention.   * + FFS: How to handle the case when there is only UL data   + FFS: The case for UE being indicated with separate UL TCI in DCI format 1\_1/1\_2 with DL assignment~~0~~ |
| OPPO | Support the propisal |
| ZTE2 | Support |

### Issue 4 (MP-UE)

The previous agreement deals with UE reporting for UE-initiated panel selection/activation. In addition, there are two more types of UE reporting proposed by companies:

* Opt1. UE report on panel-specific information (related to UE capability): Information related to the panels equipped by UE for gNB to configure UL resources accordingly
  + E.g., the total number of DL/UL panels, the max number of antenna ports/layers per panel, maximum achievable EIRP per panel, minimal switching delay between panels
  + Support: Huawei, HiSi, ZTE, LG, MediaTek, Apple, Nokia/NSB
* Opt2. UE report on panel activation/selection status (L1/L2 report): Information related to the change of activated/selected panels to refresh/reset UL measurement at gNB accordingly
  + Support: Huawei, HiSi, CATT (via MAC-CE or with existing UL transmission occasions like RACH), APT/FGI, Fraunhofer IIS/HHI, LG, Qualcomm (updating panel ID for UL resources), Samsung, Sony, NTT Docomo

In addition, some companies propose to extend the Rel-15 SRS resource definition by allowing resources with different number of ports. This is aligned with an agreed assumption that different UE panels can have different number of ports.

In light of the above, the following 3 proposals can be a good starting point for discussion.

**Table 7**

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| **Proposal 4.1**: On Rel.17 enhancements for MPUE, investigate and, if needed, specify the following:   * Support UE to report panel-specific information as a UE capability, for example:   + Information related to the total number of DL/UL panel entities   + Information related to the number of antenna ports/layers per panel entity   + Information related to the maximum number of resources per panel entity for SRS BM   + Information related to maximum achievable EIRP per panel entity   + Information related to panel switching delay * Support UE to report information related to panel activation/selection status of a panel entity * Note: above ‘panel entity’ is a logical entity and how to map physical panels to the logical entities is up to UE implementation * Note: This will depend on the final outcome of UE reporting for UE-initiated panel selection/activation   **[Proposal 4.2**: On Rel.17 enhancements for MPUE, for codebook based UL transmission, support CB based SRS resources with different numbers of ports (e.g. 2 ports+4 ports).   * FFS details (e.g. per resource or per resource set) * Note: the above is not for Rel-16 full power transmission but for Rel-17 panel-specific UL transmission]   **Proposal 4.3**: On Rel.17 enhancements for MPUE, investigate and, if needed, specify UE reporting of information related to panel activation/selection status   * FFS on reporting parameter and method (e.g. L1 or L2, updated panel ID for a UL resource (set), etc.) |

**Table 8**

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| Mod V00 | **Please share your views on the above proposals** |
| **Company** | **Input** |
| CATT | Support the proposal. |
| Vivo | Support the first one with following update.  **Proposal 4.1**: On Rel.17 enhancements for MPUE, support UE to report panel-specific information as a UE capability. Select from at least the following:   * Information related to the total number of DL/UL panel entities * ~~Information related to the number of antenna ports/layers per panel entity~~ * ~~Information related to the maximum number of resources per panel entity for SRS BM~~ * ~~Information related to maximum achievable EIRP per panel entity~~ * ~~Information related to panel switching delay~~ * Note: above ‘panel entity’ is a logical entity and how to map physical panels to the logical entities is up to UE implementation   Proposal 4.2 need further study.  Proposal 4.3 support. |
| OPPO | Proposal 4.1: Do not support. As we agreed in last meeting, specification should not be designed in such a way that the UE is required to disclose its antenna implementation. This proposal requires the UE to disclose its antenna implementations. The beam indication is through indicating a RS and the mapping between RS and UE panel/beam is controlled by the UE. Furthermore, whether UE-initiated panel selection need specification support is FFS. Before we make conclusion on that, it does not make sense to discuss UE capability.  Proposal 4.2: Do not support. That looks not part of MB enhancement. Why do we discuss it here?  Proposal 4.3: do not support. There is no use case for UE to report the panel activation/selection information. As agreed in last meeting, the mapping between panel entity and RS is controlled by the UE. We also agreed in last meeting that specification should not be designed in such a way that the UE is required to disclose its antenna implementation. The proposal 4.3 seems to ask the UE to disclose the antenna implementation. |
| MediaTek | P4.1 & P4.3: Even though we believe support of panel-specific UE capability reporting and panel activation/selection status reporting is beneficial for several cases, it would be more appropriate to discuss these issues after spec support of UE reporting for UE-initiated panel selection/activation is agreed. Thus, we suggest the following proposal instead:  **Proposal 4.1**: On Rel.17 enhancements for MPUE, investigate and, if needed, specify the following:   * Support UE to report panel-specific information as a UE capability, for example:   + Information related to the total number of DL/UL panel entities   + Information related to the number of antenna ports/layers per panel entity   + Information related to the maximum number of resources per panel entity for SRS BM   + Information related to maximum achievable EIRP per panel entity   + Information related to panel switching delay * Support UE to report information related to panel activation/selection status of a panel entity * Note: above ‘panel entity’ is a logical entity and how to map physical panels to the logical entities is up to UE implementation * Note: This will depend on the final outcome of UE reporting for UE-initiated panel selection/activation   Regarding whether reporting of panel-related information requires UE to disclose its antenna implementation, we agree with OPPO that this should carefully designed. The design should be similar to TCI state for beam indication but without disclosing how NW implement beamforming.  P4.2: Support. This is beneficial for UE power saving for MP-UE, as agreed as an use case in Rel-17. |
| LG | P4.1/P4.2/P4.3: Support.  Responding to OPPO’s comment on P4.1, please note that this proposal is about antenna ports/layers/resources, which all are logical entities written in the spec so this is not directly revealing UE implementation. Please also note that it is essential for UE to report the required number of antenna ports, layers and resources in LTE/NR, for example, FG2-3(PDSCH layers), FG2-14(CB PUSCH, which includes # of layers and resources), FG2-15(NCB PUSCH, which includes # of layers and resources, resource sets), FG2-30(SRS BM, which includes max number of SRS resources and resource sets), etc. These information are essential for gNB to allocate required DL/UL resources and to set transmission mode. For MPUE, these information such as layers/ports/resources can be different per panel so 4.1 is an essential part in order to support panel selection to our understanding.  Responding to OPPO’s comment on P4.2, the WID clearly says to specify features to facilitate dynamic panel selection and we agreed to assume that different UE panel can have different configuration(e.g. 2 port panel+4 port panel). To support dynamic panel switching between 2 port panel and 4 port panel, gNB need to configure one 2 port CB SRS resource and one 4 port CB SRS resource to the UE. Without the proposal, we cannot support dynamic panel switching for this type of UE.  Responding to OPPO’s comment on P4.3, this proposal does not intend to reveal UE implementation to our understanding. As well described in CATT’s contribution, gNB needs to refresh/reset the UL measurement when UE switches its Tx panel for a same resource transmission, resulting from the agreed UE initiated panel activation/selection. |
| Spreadtrum | It seems difficult to make progress without the same understanding on this feature. We suggest to first discuss and clarify the potential impact of switching a panel which is associated with an active TCI state. For example, whether UE can deactivate the corresponding panel without switching to an active panel for an active TCI state? If not, is there any impact when UE switch to another active panel?  For proposal 4.2, we think it should not be discussed here. Maybe in agenda 8.1.3? |
| ZTE | Support all of them. MTK’s revised version about P4.1 seems to be a good way-forward solution. |
| Xiaomi | For proposal 4.1 and 4.3, we are fine.  For proposal 4.2, it can be discussed after proposal 4.1. |
| Sony | P4.1, it seems we are not familiar with the reasons or let’s say technical rational on UE capability reporting on these parameters. Perhaps NW could imply some based on legacy capability reporting. For example, as for the 3rd bullet (Information related to the maximum number of resources per panel entity for SRS BM), if a UE carries out UL beam sweeping on a per panel level, then the highlighted parameter below was already supported starting from Rel.15 in our understanding.  ***uplinkBeamManagement***  Defines support of beam management for UL. This capability signalling comprises the following parameters:  - *maxNumberSRS-ResourcePerSet-BM* indicates the maximum number of SRS resources per SRS resource set configurable for beam management, supported by the UE.  - *maxNumberSRS-ResourceSet* indicates the maximum number of SRS resource sets configurable for beam management, supported by the UE.  P4.2, we see such flexibility seems okay.  P4.3, supportive. |
| Nokia | We do not agree with the three proposals, at least in the form in which they are captured now. Perhaps using the term ‘panel’ is an element of controversy, even that there is a clarification on the logical entity, but then we would prefer to not use this term in the agreements but rather refer to the antenna ports/layers/resources, as LGE also mentions above. |
| Ericsson | P4.1: Do not support – we may discuss this later, when we have defined if/how a panel entity would be used.  P4.2: Do not support. It is unclear how the NW would use that information  P4.3: Do not support – we may discuss this later, when we have defined if/how a panel entity would be used. |
| Fraunhofer IIS/HHI | Support 4.2 and 4.3  Support revision of 4.1 from Mediatek. |
| Mod V16 | Revised proposal 4.1 per MTK’s input which seems to be supported by a few companies and have toned down the proposal for support (7 companies raised concern on the original form).  Proposal 4.2: 6 companies raised concern. I will discuss with Hao if this can be discussed there. If not, we can see if it can be treated here.  Revised proposal 4.3 in a same manner as proposal 4.1. |
| Lenovo/MoM | Proposal 4.1: Support. Our understanding is that this does not necessarily require UE to provide its antenna implementation details.  Proposal 4.2: We are OK with this proposal, but we think it should apply to both single-panel and multi-panel. It should be discussed in this larger context.  Proposal 4.3: Support. |
| Qualcomm | For Proposal 4.1, support  For Proposal 4.2, support  For Proposal 4.3, what is the different from the 2nd bullet of Proposal 4.1? Is Proposal 4.3 for UE to report information related to mapping between panel ID and beam indication? Pls clarify |
| Apple | For proposal 4.1, we suggest the following revision. We have some concern to report panel activation/deactivation status, as we worried this may disclose some UE HW implementation aspects. Maybe the key motivation for such report it to let gNB aware potential panel switching latency.  **Proposal 4.1**: On Rel.17 enhancements for MPUE, investigate and, if needed, specify the following:   * Support UE to report panel-specific information as a UE capability, for example:   + Information related to the total number of DL/UL panel entities   + Information related to the number of antenna ports/layers per panel entity   + Information related to the maximum number of resources per panel entity for SRS BM   + Information related to maximum achievable EIRP per panel entity   + Information related to panel switching delay * Support UE to report information related to minimal switching delay for a panel based on L1 or L2 signaling * Note: above ‘panel entity’ is a logical entity and how to map physical panels to the logical entities is up to UE implementation * Note: This will depend on the final outcome of UE reporting for minimal UE switching delay for a panel   We suggest FFS proposal 4.2. Proposal 4.3 may not be needed since it is merged into 4.1. |
| OPPO | For proposal 4.2: we need more discussion on this. From our understanding, the function proposed in this proposal is already supported in rel16 full power transmission. Even through the note say this is for rel-17 panel-specific UL transmission, the scheme specified in rel16 can be applied to UE with multiple panels. Actually, the scheme specified in rel16 can be applied to UE with any number of panels, either with single panel or two panels or even more panels.  For proposal 4.1 and For proposal 4.3: Not sure why we need this proposal. Companies can study and investigate any problems even without this proposal. Furthermore, these two proposals seem to suggest to investigate something that would require the UE to that disclose its antenna implementation. The activation status of each panel belongs to UE hardware implementation and it is expected to not disclose those to the network. The mapping between RS and panel is controlled by UE. A general procedure at the UE side is: the UE determine the activation or deactivation of one panels. When the UE conducts the beam measurement, the UE can refresh and determine the latest mapping between RS and panel/Rx beam, Then the UE reports one or more CRIs or SSBRIs. For example, UE reports CRI1, CRI2, CRI3 and CRI4. The mapping between each of CRI and the UE panel/Rx beam is determined during the beam measurement. Later on, if the gNB indicates the CSI-RS resource corresponding to CRI1 or CRI2 or CRI3 or CRI 4, the UE will use the corresponding panel and beam to transmit PUSCH or PUCCH. For the gNB side, the gNB does not need to know which panel is mapped to each of CRI because such information is not needed. The gNB only needs to indicate one of those CSI-RS resources to the UE.  Regarding the UE capability, that shall be discuss after the scheme design is decided. We still do not know what kind of scheme will be specified. How come can we discuss the UE capability for “that”, which is unknown to us. |
| ZTE2 | Support revised proposals from FL. Regarding Apple’s comments, it seems that we can capture both for further study. |

### Issue 5 (MPE mitigation)

# References

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| --- | --- | --- | --- |
| 1 | R1-2103830 | Moderator summary for offline discussion on multi-beam enhancement: SSB and SRS as QCL Type-D source RS | Moderator (Samsung) |
| 2 | R1-2103220 | Moderator summary for multi-beam enhancement | Moderator (Samsung) |
| 3 | R1-2103854 | Moderator summary#2 for multi-beam enhancement: Round 1 | Moderator (Samsung) |
| 4 | R1-2103892 | Moderator summary#3 for multi-beam enhancement: Round 2 | Moderator (Samsung) |
| 5 | R1-2103930 | Moderator summary#4 for multi-beam enhancement: Round 3 | Moderator (Samsung) |