**3GPP TSG RAN WG1 #104-e R1-2101969**

**e-Meeting, January 25th – February 5th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#4 for multi-beam enhancement: Round 2B

**Document for:** Discussion and Decision

## Introduction

In this summary, the term “item 1” refers to the first item in the Rel.17 NR FeMIMO WID, i.e. multi-beam enhancement:

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| * Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:   + Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management to support higher intra- and L1/L2-centric inter-cell mobility and/or a larger number of configured TCI states:     1. Common beam for data and control transmission/reception for DL and UL, especially for intra-band CA     2. Unified TCI framework for DL and UL beam indication     3. Enhancement on signaling mechanisms for the above features to improve latency and efficiency with more usage of dynamic control signaling (as opposed to RRC)   + Identify and specify features to facilitate UL beam selection for UEs equipped with multiple panels, considering UL coverage loss mitigation due to MPE, based on UL beam indication with the unified TCI framework for UL fast panel selection |

## Summary and proposals

The summary and proposals are based on the content of the previous FL summaries R1-2101185 (preparation) and R1-2101856 (round 1).

### Issue 1 (Rel.17 unified TCI framework)

Table 1 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 1.6 | PL-RS in relation to UL TCI state and channels | Alternatives:   * **PL-RS included in UL TCI state:** IDC, Ericsson (optional for DL RS), Apple (only valid when SRS is configured for beam indication), vivo (in case of DL RS in TCI state), MTK (for no PL-RS configured, and DL CSI-RS or SSB), Intel, AT&T, OPPO (separate RS), Fraunhofer IIS/HHI (separate RS), Qualcomm, Lenovo/MoM, Xiaomi, NTT Docomo, OPPO, Nokia/NSB (QCL-TypeD RS if periodic and no PL-RS configured /associated), LG * **PL-RS associated with UL TCI state:** Futurewei, Spreadtrum, Nokia/NSB, Huawei/HiSi, MTK, Sony, Qualcomm (separate field in the same DCI), CATT, NTT Docomo, ZTE, CMCC * **PL-RS not associated with UL TCI state:** Ericsson (in case of UL RS in TCI state) * **Use Rel-16 PL-RS framework:** vivo (for UL RS in TCI state)   MAC CE configures association between activated TCI states and PL-RS/PC: CATT, MTK(PL-RS only), Sony(only PL-RS) | |

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| **(from Round 2) Proposal 1.1 (for discussion only)**: On Rel.17 unified TCI framework:   * When a periodic DL-RS is used as a source RS for determining spatial TX filter in the UL or, if applicable, joint TCI state, select one of the following alternatives by RAN1#104bis-e:   + [Alt1: PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter in UL or (if applicable) joint TCI state.   + Alt2: PL-RS is always included in in UL TCI state or (if applicable) joint TCI state] * When a periodic DL RS used as a source RS for determining spatial TX filter is not configured in the UL or, if applicable, joint TCI state, select one of the following alternatives by RAN1#104bis-e:   + Alt1. PL-RS is always included in UL TCI state 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]   + Alt3. 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 in UL TCI state or (if applicable) joint TCI state or configured as the QCL/spatialRelationInfo source of the RS in UL TCI state or (if applicable) joint TCI state] * FFS: Application time of PL-RS * NOTE: As in Rel-16, a UE does not expect to simultaneously maintain more than four pathloss estimates per serving cell for all PUSCH/PUCCH/SRS transmissions |

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| Action: Please answer the questions below. The purpose is to see if we can reduce # alternatives:   1. Light blue highlight: Is it okay to remove Alt2 and refine Alt1 to address the monitoring issues raised by, e.g. Qualcomm and Futurewei in round 2? 2. Purple highlight: Alt4 can be thought as a special case of Alt2 (instead of Alt1). Is that correct? If so, can we replace Alt2 with Alt4 (more specific solution)?   Goal: Finalize the proposal to be ready for endorsement |

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| **Revised Proposal 1.1**: On Rel.17 unified TCI framework:   * Select one of the following alternatives by RAN1#104bis-e for 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 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 in UL or (if applicable) joint TCI state   + Alt3. 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 QCL-Type-D/spatialRelationInfo source of the source RS in UL TCI state or (if applicable) joint TCI state * FFS: Application time of PL-RS * FFS: Choosing between Alt1 and Alt2 may be up to RAN2 decision * 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 |

Table 2 Inputs: issue 1

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| **Company** | **Input** |
| Moderator | 1.1: Starting from the last version at the end of round 2. Please answer the questions. Narrowing down alternatives help progress in the next meeting. |
| Apple | Yes to both questions. Since the condition changed, we can formulate Alt4 as follows:  Alt4. UE calculates path-loss based on periodic DL RS configured as the QCL/spatialRelationInfo source of the RS in UL TCI state or (if applicable) joint TCI state  {Mod: Done, please check new version (also with MediaTek’s addition)} |
| MediaTek | To the first question, we are okay to leave it to the next meeting, or at least the 2nd bullet has a conclusion.  To the second question, we think it may be difficult to merge Alt2 and Alt4. On Alt2, most of the proposals are going to use some explicit signaling (RRC, MAC-CE, or DCI) to provide the association. However, on Alt4, PL-RS is implicit determined according to QCL chain. Pros can cons between them can be discussed in the meeting. Some change on Apple’s version to make Alt4 more clear.   * Alt4. UE calculates path-loss based on a periodic DL RS configured as the TypeD-QCL/spatialRelationInfo source of the source RS in the UL TCI state or (if applicable) joint TCI state   {Mod: Agreed, done} |
| Docomo | Yes for both questions. We agree with Apple/MediaTek’s modification on Alt.4. |
| Nokia/NSB | Light blue:  We don’t think Alt 1 can work without causing restriction on # of different QCL source RS. We have preference to utilize Qualcomm’s previous version as 1st main bullet. But as respect to FL’s moderation, we suggest to change Alts as follows:   * + Alt1: PL-RS can be associated with UL TCI state or (if applicable) joint TCI state. If not associated, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter in UL or (if applicable) joint TCI state.   + Alt2: PL-RS is always included in in UL TCI state or (if applicable) joint TCI state   Purple:  Main of the 2nd bullet has been changed. When UE cannot find periodic DL-RS as QCL source RS, UE should find explicit indication of PL-RS somewhere. So Alt 2 needs to be changes as:   * + Alt2. PL-RS is ~~can be~~ associated with (but not included in) UL TCI state or (if applicable) joint TCI state   We don’t think Alt 4 in purple is related with Alt 2. We are still O.K. to delete Alt 4.  {Mod: Agreed, thanks, done} |
| Samsung | For the first question, it is not clear what the changes to Alt1 will be if Alt2 is removed, so we prefer to keep both alternatives for now.  For the second question, we agree that Alt4 can be consider as a special case of Alt2. We are fine to remove Alt2 and keep Alt4. We also agree with the change for Alt4 proposed by MediaTek. Periodic DL RS is not part of the alternatives for the second main bullet. |
| vivo | Yes to both questions.  For the first question, to address QC/FutureWei’s concerns, if Alt1 requires larger number of PL-RS for UE to track for some cases, Rel-16 scheme could always be a fallback. |
| Qualcomm | For Q1: No. Added Alt3, which is ZTE’s proposal to address our concern. Alt1 is the original proposal without addressing the concern. Alt2 may not be flexible. Also, there is no agreement on whether/how to support R16 scheme in R17. Even if it is supported in R17, UE capability may not support it. So fallback to R16 suggested by Vivo may not be a feasible/general solution   * + Alt3: If no PL RS is additionally configured in or associated to UL TCI state or (if applicable) joint TCI state, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter in UL or (if applicable) joint TCI state.   {Mod: Please check the revised Alt1 (from Nokia) which, I believe, addresses your concern without adding another alternative}  For Q2: No. Alt2 and Alt4 are fundamentally different to our understanding. Alt2 means association is explicitly indicated by gNB. Alt4 means PL RS is implicitly derived from the QCL source RS of the RS in TCI state.  In general, we prefer the ZTE’s original wording for the whole proposal.  **Proposal 1.4**: On Rel.17 unified TCI framework:   * When a PL-RS is not explicitly associated or included in the UL or, if applicable, joint TCI state, a periodic DL RS used as a source RS for determining spatial TX filter ~~is~~ in the UL or, if applicable, joint TCI state, ~~the periodic DL RS~~ is the PL-RS * ~~When a periodic DL RS used as a source RS for determining spatial TX filter is not configured in the UL or, if applicable, joint TCI state~~Otherwise, select one of the following alternatives by RAN1#104bis-e:   + Alt1. PL-RS is always included in UL TCI state 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   + Alt3. Reuse Rel.16 procedure (MAC CE+DCI based) to indicate PL-RS for UL transmission without enhancement   + Alt4. UE calculates path-loss based on periodic DL RS configured as the QCL/spatialRelationInfo source of the RS in UL TCI state or (if applicable) joint TCI state * FFS: Application time for PL RS   {Mod: Several companies have raised some concern that “Otherwise” is not clear (cf. round 2 summary). The current skeleton seems fine to most companies. } |
| Futurewei | On the first bullet/first question, we have some concerns and suggest removing the first bullet:   1. If the UE’s capability of tracking multiple RSs for pathloss measurement does not increase, e.g., follow the one indicated in the note, then the number of different QCL source RSs in Rel. 17 unified TCI framework will be highly limited, and the Rel. 17 unified TCI framework might not work. 2. It is not clear how the UE maintains pathloss measurement on the PL-RS if the PL-RS is a source RS for determining spatial TX filter in the UL or, if applicable, joint TCI state, and the beam is not active. In our opinion, PL-RS needs to be measured irrespective to whether the beam is active or not so separation of TCI/QCL RS from PL-RS needs to be provided, and association is a good approach.   {Mod: Please check the revised version of Alt1 (from Nokia) whether it addresses your concern.}  On the second question, Alt.2 and Alt.4 are different and we are ok to remove Alt.4. |
| Lenovo/MoM | Yes to both questions.  For the first question, we think Al1 is clear enough to be adopted. We think the concern of Futureway can be addressed by gNB implementation.  For the second equestion, we agree with Apple’s change. |
| Huawei, HiSilicon | Light blue: We are not sure how merging Alt-2 into Alt-1 can address monitoring issues raised by Qualcomm/FutureWei. Instead, we think association instead of direct inclusion can help mitigate monitoring limitations. In this sense, we support the modification from Nokia (to add ‘can be associated with…’).  Purple: We share similar view as MediaTek/Nokia that Alt-2 (explicit association) and Alt-4 (implicit derivation) are different and should not be merged. And we support modifications from MediaTek and Nokia for better clarity. |
| Moderator | Revised proposal 1.1 includes the proposed modifications. No merging is performed. So it should be relatively stable since it hasn’t changed much from the last version (with all the alternatives still intact, except one) |
| ZTE | Support the revised proposal 1.1.  Small suggestion: It seems that current framework of this revised proposal is a little bit wired. Alt 1 in first bullet is a complete solution that is also relevant to second bullet. The motivation of splitting two bullets is due to the fact that we try to agree the implicit determination of periodic DL RS in TCI state as PL RS. Clearly it does not work due to some companies also want to have an explicit PL RS for handling the imbalance of total numbers of activated TCI state (up to 8 at least?) and activated PL RS (up to 4 as clarified in last note). Since then, we can re-organize this proposal as follows as a suggestion for cross review.  FYI, I add one note for clarifying following ‘associated with’ can represent either “included in” or “mapped to but not included in”.  **Revised Proposal 1.1**: On Rel.17 unified TCI framework, select one of the following alternatives by RAN1#104bis-e:   * Alt1: PL-RS can be associated with the UL TCI state or, if applicable, joint TCI state. If not associated, PL-RS is the periodic DL-RS used as a source RS for determining spatial TX filter in UL or (if applicable) joint TCI state. * Alt2: PL-RS is always associated with UL TCI state or (if applicable) joint TCI state * Alt3. 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 in UL TCI state or (if applicable) joint TCI state, or configured as the QCL-Type-D/spatialRelationInfo source of the source RS in UL TCI state or (if applicable) joint TCI state * Note: above ‘associated with’ can represent either “included in” or “mapped to but not included in”. * FFS: Application time of PL-RS * NOTE: As in Rel-16, a UE does not expect to simultaneously maintain more than four pathloss estimates per serving cell for all PUSCH/PUCCH/SRS transmissions   {Mod: I think I finally understand your point. But I don’t want to mix up association with inclusion. Please see the revised version.} |
| MediaTek | We share similar observation with ZTE. If Alt1 in the main bullet is agreed, then we don't have to discuss the second bullet. We are afraid that it is difficult to list all combinations in this proposal. Even in the ZTE’s revision, we believe Alt3 and Alt4 are still not a complete solution. Thus, we still prefer FL’s original suggestion to remove alternatives in the first bullet, and discuss it when the 2nd bullet has a conclusion.  {Mod: Understood. Please check the revision – I think it should address your point.} |
| Moderator | If I understand correctly, the points raised by Bo/Yan/Darcy/Emad/Dan/Zhigang can be paraphrased as follows: 1) Even if periodic DL RS is available as a source RS for UL spatial filter, its use for PL-RS should not be automatic/mandatory. 2) Hence, all the alternatives for the second bullet should be applicable in all circumstances.  I revised proposal 1.1 based on this understanding. |
| NEC | Support the FL proposal. |
| Apple | Since we merged the two cases again, we suggest we change Alt4 back as follows:   * + Alt4. UE calculates path-loss based on periodic DL RS configured as the source RS or the QCL-Type-D/spatialRelationInfo source of the source RS in UL TCI state or (if applicable) joint TCI state   {Mod: Thanks for keeping track, Yushu. Sorry for switching back and forth.} |
| Qualcomm | Support the revised Proposal 1.1 |
| ZTE | Support the FL proposal.  One clarification for our intention for merging Alt1 ‘be included in’ and Alt2 ‘be associated with’ is that the issue of selecting one of them may be details of RAN2 RRC signaling. As we usually did in Rel-15/Rel-16, this issue can be a RAN2 issue and up to RAN2 final decision. If possible, we prefer to add the following FFS as in a sub-bullet.   * + FFS: Choosing between Alt1 and Alt2 may be up to RAN2 decision.   {Mod: Thanks, that’s a good point} |
| Xiaomi | For the first question, yes. And we are fine to the revised Alt 1 from Nokia or the Alt 3 from Qualcomm.  For the second question, we share the same view that Alt2 is an explicit way and Alt 4 is an implicit way.  We support the revised proposal 1.1. |

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

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.2 | Type of beam metric for measurement and reporting:  L1-RSRP or L3-RSRP | Alternatives**:**   * **L1-RSRP (19):** vivo, MTK, Samsung, Qualcomm (L3 can reuse existing), Intel (intra-DU can re-use L1-RSRP), Xiaomi, Sony, NTT Docomo, ZTE, Ericsson, Nokia/NSB, Futurewei, Huawei/HiSi, IDC, APT, ASUS, CMCC * **L3-RSRP (4):** OPPO, Lenovo/MoM, Xiaomi (L3-RSRP only for triggering beam measurement of non-serving cell) * **Hybrid L1+L3-RSRP (2):** Apple, CATT (with SD filter L3-RSRP) |

Note that this issue is relevant not only for L1/L2-centric inter-cell mobility, but also for inter-cell mTRP. Based on the above summary, the following proposals are made:

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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:   * Rel.15 L1-RSRP is used as reporting quantity for measurement and reporting of non-serving-cell(s)   + Support SSB as a measurement RS for L1/L2-centric inter-cell mobility and inter-cell mTRP, and Rel.15 SS-RSRP calculated from SSB of non-serving cell(s)     - FFS: Whether the measurement for SS-RSRP is limited within SMTC   + FFS: Whether or not to support CSI-RS (for e.g. mobility and/or tracking) of non-serving cell(s) as a measurement RS for L1/L2-centric inter-cell mobility and inter-cell mTRP. If supported, Rel.15 CSI-RSRP is also supported     - FFS: Whether the support applies to CSI-RS with or without QCL source, or both   + FFS: The number of non-serving cell(s) for measurement/reporting   + FFS: time behavior of the reporting, i.e. periodic, semi-persistent, or aperiodic * FFS: If other reporting quantities are supported, e.g. L3-RSRP, hybrid L1/L3-RSRP * FFS: Dynamic activation/deactivation/selection of the beam measurement on the RS(s) associated with non-serving cell(s) via MAC CE * FFS: Timing assumption for measurement of non-serving cell RS measurement |

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| Action: Interested companies are encouraged to provide their inputs on the proposal  Goal: Finalize the proposal to be ready for endorsement |

Table 4 Inputs: issue 2

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| **Company** | **Input** |
| Moderator | 2.1 is almost stable from round 2. One contention point raised by OPPO is on the number of cells the UE needs to measure and report. OPPO’s point is acknowledged, i.e. K beams can be associated with a single non-serving cell (NSC). But several companies have expressed that they are not ready to agree on the number of cells. I added an FFS for this. |
| Apple | We would like to clarify the dynamic activation/deactivation a little bit, and apologize for missing clarification in last round.  The intention is for aperiodic report for periodic RS, e.g. SSB. Since UE does not know when aperiodic report would be triggered, it has to get ready for the report – UE needs to keep measuring the SSBs. This would lead to two issues: 1) UE power consumption; 2) overhead – gNB cannot transmit data/control in that resource since UE is measuring SSBs.  {Mod: Added clarification along the line suggested by MediaTek } |
| MediaTek | Now we understand Apple’s opinion. To our understanding, it not possible to deactivate SSB measurement if it is configured for L1-RSRP measurement based on current CSI-RS framework. It would be good to have a dynamic activation command to activate/deactivate the SSB measurements. We suggest to update the FFS to make it more clear:  FFS: Dynamic activation/deactivation of the beam measurement on non-serving cell(s) RS by MAC CE  On the CSI-RS, it would be better to clarify whether or not to support CSI-RS (for e.g. mobility and/or tracking) as a measurement RS for L1/L2-centric inter-cell mobility and/or inter-cell mTRP.  Support Rel.15 CSI-RSRP if CSI-RS (for e.g. mobility and/or tracking) is supported as a measurement RS for L1/L2-centric inter-cell mobility and/or inter-cell mTRP   * FFS: Whether or not to support CSI-RS (for e.g. mobility and/or tracking) as a measurement RS for L1/L2-centric inter-cell mobility and/or inter-cell mTRP * FFS: Whether the support applies to CSI-RS with or without QCL source, or both |
| Docomo | Support the proposal 2.1.  For the FFS of dynamic activation, we would like to support aperiodic beam reporting on periodic RS (e.g. SSB) on non-serving cell, same as Rel.15 on serving cell. Regarding to Apple’s two issues, we think these issues exist for periodic beam reporting too. But, this is FFS part, we can discuss it on next meeting. |
| Nokia/NSB | O.K. in principle |
| Samsung | We support proposal 2.1, but have some clarifications:   * The wording of the second sub-bullet of the first bullet is a bit awkward. Maybe we can reword to:   FFS: support of CSI-RSRP, CSI-RS for mobility, TRS as a measurement RS for L1/L2-centric inter-cell mobility and/or inter-cell mTRP  FFS: Whether the support applies to CSI-RS with or without QCL source, or both  {Mod: The intention of this bullet (from Nokia in round 2) was to clarify that if CSI-RS can be used as a measurement RS for L1-RSRP, Rel.15 CSI-RSRP is automatically supported. So there is no need for FFS (which is correct – it is strange to support only SS-RSRP if CSI-RS can be configured as a measurement RS). But I agree the wording was awkward and is now revised.}   * The second clarification is about the last FFS, what is the meaning of “timing assumption”, is this the timing of the arriving signal from the non-serving cell (i.e. in reference to propagation delay), or the timing of when the measurement will take place.   {Mod: It is the first one, I believe.} |
| vivo | We are fine with the proposal.  For the dynamic activation/deactivation of beam measurement, we would like to update a little bit as following based on FL proposals:  FFS: Dynamic activation/deactivation/selection of non-serving cell(s) for beam measurement by MAC CE |
| Qualcomm | We support the current Proposal 2.1 |
| Futurewei | We agree with FL’s proposal in principle. |
| Lenovo/MoM | Support in principle. We cannot see any difference in the activation/deactivation part of intra- and inter-cell beam measurement, so we think the second FFS should be removed. This part can reuse the R16 mechanism.  {Mod: This FFS is to allow proponent(s) to present their case more thoroughly. If there is not enough interest/support, it will not happen anyway. I believe it doesn’t harm to give more time for other companies to think about it more.} |
| Huawei, HiSilicon | Ok in principle, and support the revisions from MediaTek, and we do not support the wording revision from Samsung (as it removes conditional support of CSI-RSRP, and we did not hear any technical reasons not to support CSI-RSRP from Rel-15).  {Mod: Agreed} |
| Moderator | Proposal 2.1 is revised and relatively stable. |
| ZTE | Support |
| MediaTek | Support Proposal 2.1 |
| Moderator | Proposal 2.1 is quite stable. I just added a bullet point to make the support of SSB as a measurement RS explicit, and moved the FFS for CSI-RS from 3rd bullet point to 1st bullet point |
| InterDigital | We are fine with the proposal except the sub-bullet on Rel.15 CSI-RSRP. We prefer to discuss it together with “Whether or not to support CSI-RS as a measurement RS” and want to consider the sub-bullet as FFS. |
| Moderator | Modified structuring of proposal 2.1 per IDC’s comment |
| NEC | Support the FL proposal. |
| Apple | Support the FL proposal.  To Lenovo, there is no R16 mechanism to dynamically activate/deactivate a CSI-reportConfig. When a CSI-reportConfg is provided by RRC, UE has to take some action – measuring corresponding RS, as it does not know when the report would be triggered. |
| Qualcomm | Support the latest Proposal 2.1 |
| ZTE | Support the FL proposal |
| Xiaomi | Support the Proposal 2.1. |

### Issue 3 (beam indication signaling medium)

Table 5 Summary: issue 3

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 3.1 | Beam application time definition:  Alt1: Measured from DCI reception  Alt2: Measured from ACK transmission | **Alt1 (DCI) (7):** Spreadtrum, Xiaomi, Ericsson, CATT, MTK, NEC, Samsung  **Alt2 (ACK) (17):** IDC, Lenovo/MoM, Fujitsu, Nokia/NSB, CMCC, Apple, Huawei/HiSi, ZTE, vivo, Intel, Sony, Qualcomm, NTT Docomo, APT  **Alt1 and Alt 2:** OPPO (Since Alt1 considers the requirement of UE and Alt2 considers the requirement of gNB side), LG | |
| 3.4 | Support for additional DCI formats for Rel.17 unified TCI framework beam indication (TCI state update) | DCI formats 1\_1/1\_2 without DL assignment:   * **Yes (18)**: OPPO, Fujitsu, Spreadtrum, Nokia/NSB, CATT, vivo (at least for UL-only TCI), MTK, Qualcomm, Samsung, Apple (ACK/NACK mechanism is needed), vivo, Lenovo/MoM, Convida, NTT Docomo, ZTE (ACK/NACK is needed), NEC (ACK/NACK needed) * **No (4)**: Ericsson, Huawei/HiSi, LG   DCI formats 0\_1/0\_2 with UL grant:   * **Yes (10)**: IDC, Nokia/NSB, Xiaomi (at least for UL-only TCI), ZTE (at least for UL-only TCI), MTK, LGE, Intel, Sony (Study), Qualcomm * **No (12)**: OPPO, CMCC, Ericsson, Huawei/HiSi, Convida, Apple, vivo, Spreadtrum, CATT, NTT Docomo, NEC   Dedicated DCI format for beam indication, with dedicated ACK based on SPS PDSCH release:   * **Yes (15)**: Futurewei, ZTE, CATT, Intel, Sony, NTT Docomo(keep the same DCI payload as existing DCI format), OPPO (based on format 1\_0 without DL assignment), Samsung, Nokia/NSB (based on format 0\_1/0\_2 without UL grant), Qualcomm, Lenovo/MoM, APT (based on SPS or CG release DCI), NEC * **No (8)**: Ericsson, MTK, Convida, Apple, vivo, Huawei/HiSi, LG   **Support extending existing DCI formats for UL-only TCI**: APT | |

Additional DCI

From Table 5, the reuse of DCI formats 0\_1/0\_2 with UL grant is unlikely agreeable (10 support vs 12 oppose). The remaining alternatives should be down selected.

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| **Proposal 3.1**: On the Rel.17 DCI-based beam indication, in RAN1#104bis-e, down-select one of the following alternatives regarding the support of DCI format(s) for beam indication in addition to the agreed DCI formats 1\_1/1\_2 with DL assignment (in RAN1#103-e):   * Alt0: No additional DCI format is supported * Alt1: DCI formats 1\_1 and 1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI   + Support DCI acknowledgment mechanism, e.g. based on SPS PDSCH release, based on triggered SRS, based on DCI indicating SCell dormancy   + FFS: How to identify DCI formats 1\_1/1\_2 used for beam indication only (not for scheduling a PDSCH reception, not indicating a SPS PDSCH release, or not indicating SCell dormancy), considering impacts on PDCCH coverage and scheduling mechanism   + FFS: Whether the UE can/shall assume the gNB configured application time is after ACK transmission * Alt2: Dedicated DCI format other than 1\_1/1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI   + Support DCI acknowledgment mechanism, e.g. based on SPS PDSCH release, based on triggered SRS, based on DCI indicating SCell dormancy   + FFS: If the format is based on an existing DCI format, how to identify the DCI format used for beam indication only   + FFS: Whether the UE can/shall assume the gNB configured application time is after ACK transmission |

Beam Application Time (BAT)

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| Previous agreement (RAN1#103-e):  On Rel.17 DCI-based beam indication:   * Regarding application time of the beam indication: if beam indication is received, down-select from the following:   + Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication   + Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication   + FFS: whether any existing timing defined for DCI based TCI/spatial relation update can be used for X/Y * FFS: When to apply the minimum indication delay (e.g., when the newly indicated beam is different with the previously indicated beam) |

The main arguments for Alt1 (assuming the agreed DCI formats 1\_1/1\_2 with DL assignment):

* It tends to result in lower beam application latency than Alt2
* Unlike Alt2, for the agreed DCI formats 1\_1/1\_2 with DL assignment, it allows the updated TCI state (signaled in the DCI) to be used for the DL assignment (PDSCH reception) associated with the beam indication DCI provided that the offset between the DCI and the PDSCH resources used for the DL assignment is larger than the threshold. This is not possible in Alt2 since the updated TCI state can be active only after the ACK transmission (hence after the DL assignment).

The main arguments for Alt2 (assuming the agreed DCI formats 1\_1/1\_2 with DL assignment):

* Unlike Alt1 where potential misalignment between gNB and UE assumptions on the TCI state can occur if the DCI is not successfully decoded, Alt2 ensures that the gNB and the UE are aligned (since the gNB can assume that the TCI state update is successfully received after receiving the ACK from the UE).

Assessment: It is argued that since PDCCH error rate is around 1%, the probability of TCI state assumption misalignment associated with Alt1 is 1% (non-negligible), thus Alt2 is preferred.

* However, this reasoning ignores that the misalignment only occurs between the DCI reception and ACK transmission –typically a significantly smaller fraction of the overall UE data traffic even if the UE receives DL assignment in every slot.
* Furthermore, this misalignment (only in a relatively small time period) only occurs for other PDCCH transmission (than the beam indication DCI) and other PDSCH/PUSCH transmissions (not associated with the DL assignment). It does not apply to the DL assignment associated with the beam indication DCI. Nor does it apply to PUCCH resource used for the ACK.
* Furthermore, it is argued that since BAT is configured by the gNB (given the UE capability), the gNB can configure the BAT depending on factors, e.g. UE data traffic, resource allocations, such that the chosen value avoids or minimizes the misalignment while still ensuring lower beam application latency compared to Alt2. Obviously a sufficiently large BAT for Alt1 can replicate the effect of Alt2, but the converse doesn’t always hold.
  + In other words, the potential misalignment between gNB and UE assumptions on the TCI state is in principle a gNB implementation issue, not so much UE procedural issue

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| Proposal 3.2: On Rel.17 DCI-based beam indication, |

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| Action: Interested companies are encouraged to provide their inputs on:   * Proposal 3.1 on DCI format * Beam application time (BAT): Alt2 proponents to provide counter-arguments to the arguments from Alt1 proponents (in short, Alt1 can be used and the potential misalignment is in principle a gNB implementation issue, not so much UE procedural issue, since BAT is selected/configured by the gNB)   Goal:   * Proposal 3.1: Finalize the proposal for endorsement * BAT: Arrive at a proposal to down select Alt1 vs Alt2 |

Table 6 Inputs: issue 3

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| **Company** | **Input** |
| Apple | Support Alt1 in proposal 3.1. When gNB has no downlink data for transmission, Alt1 can be helpful to avoid dummy data transmission. Dummy data transmission would waste both gNB and UE power. |
| MediaTek | Support Proposal 3.1.  On BAT, we prefer Alt1. We believe FL already captures the arguments why the reliability of Alt1 is not a problem, and the benefit of Alt1 is clear. |
| ZTE | Proposal 3.1: Alt1 is supported. Besides wasting resources as Apple mentioned, BLER for PDSCH is about 10%, and consequently rate of transmission failure is at least 10 times over successful PDCCH decoding. If we just try to list candidate for down-selection next meeting, we think that the following “FFS” in Alt1 can be removed.   * Alt1: DCI formats 1\_1 and 1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI   + support DCI acknowledgment mechanism, e.g. based on SPS PDSCH release, based on triggered SRS   + FFS: How to identify DCI formats 1\_1/1\_2 used for beam indication only, not scheduling a PDSCH reception, indicating a SPS PDSCH release or indicating SCell dormancy   Regarding BAT, we support Alt.2. Maybe, this discussion should be postponed until we make the final down-selection for candidates in Proposal 3.1. |
| vivo | Support Alt1 in proposal 3.1  Support Alt2 in proposal 3.2. |
| OPPO | Either Alt 1 or Alt 2 in proposal 3 is ok to me.  For Alt1: the benefit is we can remove the dependency of beam indication on PDSCH transmission.  For Alt2: a dedicated DCI can reduce the overhead of beam indication and also improve the reliability of DCI-based beam indication. |
| Sony | For proposal 3.1, support Alt.2.  Reusing the existing DCI format 1\_1 or 1\_2 without DL assignment may not be flexible enough to conduct all necessary information related to TCI state(s) to be applied. So for the newly defined function in Rel.17, it seems proper to design a dedicated DCI format for it.    For BAT, support Alt.2.  It may sound a little conservative that beam updating based on DCI should be 100% aligned at both NW and UE side. Consider a case (perhaps a corner case) that the DCI carrying new TCI targets for PDCCH itself, if the 1% PDCCH decoding failure happens, there could be beam misalignment for PDCCH, which may results in undesirable BFR. |
| Nokia/NSB | Proposal 3.1: Support Alt 1  Proposal 3.2: Support Alt 2. But we are O.K. for further discussion on applying new beam to scheduled/granted PDSCH/PUSCH which is already supported feature in Rel-15/16. We have most concerns on ‘differentiating’ beams between TCI indication DCI and acknowledging N/Ack PUCCH. |
| Futurewei | Support Alt2 in Proposal 3.1. The existing DCI format 1\_1 or 1\_2 without DL assignment lacks the capability to provide information for beam indication for single channel (e.g. PDSCH only, single CORESET) or a subset of channels. |
| Convida Wireless | Support the FL proposal 3.1. Prefer Alt 1. |
| Lenovo/MoM | Proposal 3.1: We agree this shall be decided in RAN1#104bis-e meeting, but we think Alt1 and Alt2 shall not be exclusive. For Alt 1 we agree with Apple’s argument on not wasting UL power. For Alt 2 we think it has the benefit for signaling many UEs simultaneously for reduced delay. Companies should bring back arguments supporting for or against each alternatives for RAN1 to decide in the next meeting.  Proposal 3.2: we support Alt 2 to ensure the ACK is received by the gNB before the new beam is activated. |
| Qualcomm | Added one more example    **Proposal 3.1**: On the Rel.17 DCI-based beam indication, in RAN1#104bis-e, down-select one of the following alternatives regarding the support of DCI format(s) for beam indication in addition to the agreed DCI formats 1\_1/1\_2 with DL assignment (in RAN1#103-e):   * Alt0: No additional DCI format is supported * Alt1: DCI formats 1\_1 and 1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI   + FFS: support DCI acknowledgment mechanism, e.g. based on SPS PDSCH release, based on triggered SRS, based on DCI indicating SCell dormancy   + FFS: How to identify DCI formats 1\_1/1\_2 used for beam indication only, not scheduling a PDSCH reception, indicating a SPS PDSCH release or indicating SCell dormancy * Alt2: Dedicated DCI format other than 1\_1/1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI   + Support DCI acknowledgment mechanism based on SPS PDSCH release   FFS: If the format is based on an existing DCI format, how to identify the DCI format used for beam indication only  For potential proposal 3.2, the reliability of Alt.1 may be ensured by configuring the application time after the acknowledgement, so both sides will switch the beam only after the acknowledgement is Txed/Rxed. We are fine for either modified Alt.1 or Alt.2 below.   * + Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication     - The gNB configured application time should be after the acknowledgement.   + Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication   {Mod: Please check rewording using 214-type language (UE assumption). Since some Alt1 proponents may not agree to this, it is an FFS}. |
| Ericsson | Support proposal 3.1. Just as was predicted in previous meeting, DCI design takes a long time, and this discussion needs to be finalized.  For BAT: we agree with Qualcomm that with Alt1, the gNB can still configure the application time to be after the ACK – this is up to NW configuration. We think that is the reasonable configuration, but in the future, things may change, and we do not want to stop other NW vendors to perform more aggressive configurations. Therefore, we prefer Alt1, but we would be OK with Alt2 as well. |
| Huawei, HiSilicon | Proposal 3.1: Support Alt-0. Object Alt-1/2.  Proposal 3.2: Support Alt-2. Alt-1 is unnecessarily complicated in terms of timeline planning and beamforming behavior determination, i.e., needs to consider UE capability and gNB configuration, and compare time offsets between DCI and PDSCH and ACK and the effective application time (with which the receiving beam for PDSCH and Tx beam for ACK can only be determined after decoding the DCI). Alt-2 can also help avoiding the complicated misalignment handling and PDCCH/PUCCH/PUSCH grouping mentioned in the assessment part. |
| Intel | Proposal 3.1: We support Alt. 1 since it can also enable UL-only beam indication without DL grant when formats 1\_x is used. It is not reasonable to couple UL-only beam update e.g., for HetNet or MPE scenario, with a DL PDSCH transmission. We are also open to Alt. 2 since it can increase flexibility of beam indication. We would like to note that we have still not resolved FFS points from RAN1#103e about applicability of the indicate DL/UL or joint TCI to a subset of channels/RS or to individual channels RSs. Selecting Alt. 0/1 without scope for Alt. 2 would preclude any such option.  Proposal 3.2: Support Alt. 2 We think some of this discussion is also dependent on the outcome of Proposal 3.1. For example, if DCI for beam indication-only (DL grant free) is supported and we also support HARQ feedback for this beam indication DCI, it makes little sense to change the beam before the feedback is transmitted. Notwithstanding the arguments on the benefits of the applicability of indicated beam to scheduled PDSCH in Rel-16, the unified TCI framework has a wider scope than legacy TCI indication. Here the updated beam can be used for control channel reception and for ACK/NACK transmission as well. It might not make sense to apply the beam before acknowledgement of such beam indication is transmitted. If UE misses DCI, then misalignment can occur. We also wonder what the point is, of agreeing on a HARQ feedback for the beam indication DCI if beam is changed before transmission of the ACK? |
| Samsung | Support proposal 3.1. We are fine with Alt1 and Alt2, but slightly prefer Alt2.  For the beam application time (BAT), we prefer Alt1. As explained by the FL, BAT configured by gNB can be configured large enough with Alt1 so as to mimic the Alt2 timing. However, Alt2 can’t mimic Alt1. In some scenarios, the application of the DCI-indicated TCI state to the PDSCH associated with the DCI can be improve reception quality of the PDSCH, if there is no other simultaneous downlink/uplink traffic there is no beam misalignment risk. |
| APT | Support Proposal 3.1. The first FFS in Alt 1 can be removed from our perspective.  Related to BAT, support Alt-2. |
| Moderator | Proposal 3.1 should be stable.  On BAT, some companies seem to be repeating their previous arguments in previous round rather than interacting with the arguments from the opponents (or the above summary ☺). I tend to agree with, e.g. ZTE and Intel, that the benefit of Alt1 over Alt2 depends on whether an additional DCI format is supported or not. So this can be discussed and decided together in the next meeting. At the same time, some online conversation is needed. I feel some points didn’t come across. For those who haven’t read the above summary, please do so, and interact (debate) with the points raised by Alt1 proponents. |
| LG | On Proposal 3.1, we support Alt0 and we still think that the existing DCI formats (0\_1/0\_2) should be taken into account on the same table. We can separate three cases.  Case1: when there is DL-SCH to send to UE  Case2: when there is UL-SCH to be transmitted from UE  Case3: when there is no DL-SCH and no UL-SCH  For Case1, the agreed method is sufficient. For Case2, we think that it is straight-forward to use the UL DCI in which UL TCI field exists, i.e. DCI format 0\_1 and 0\_2. For Case 3, we are not sure why beam switching should be done so quickly since there is no data to send/receive, so it is not of high priority scenario to our understanding. Case 3 can be handled by implementation using the methods defined for Case1/Case2 or via MAC-CE based beam indication since there is no PDSCH/PUSCH scheduling.  On BAT, our main concern on Alt2 is that if there is a TCI field in DCI, why this TCI indication cannot be applied to the scheduled PDSCH/PUSCH by the DCI? This function is already well supported in Rel-15/16 and should be supported in Rel-17 as well. If Alt2 is a way to go, PDSCH should be an exception. We don’t quite understand some companies’ argument that BAT should be aligned for different channels. UE cannot receive PDSCH and PDCCH at the same time anyway, and UE cannot transmit PUCCH/PUSCH while receiving PDCCH/PDSCH in TDD, where we believe that we are discussing on FR2 TDD system. |
| Moderator | Proposal 3.1 is relatively stable.  Re BAT, we can continue discussion to gain better understanding. Alt2 proponents argued they want to avoid misaligment. But they have not addressed the counter-arguments from Alt1 proponents (or LG/NTT Docomo proposal to use Alt1 for DL assignment/PDSCH associated with the DCI).   * Alt2 proponents, please provide counter arguments against Alt1 or mixed-BAT proponents (see blue text) |
| Apple | For BAT, we support Alt2.  The gNB would indicate a new beam when it is with better quality, where current beam may or may not work well. So it is hard to say miss detection ratio of beam indication PDCCH can hardly happen.  Then the problem becomes what would happen if UE misses the PDCCH. If gNB does not know this PDCCH is missed, NW-UE beam pair miss match would happen. So it is necessary for gNB to know whether the PDCCH is missed or not. Only after UE reports ACK/NACK, gNB can know whether it is received by UE or not. But gNB may not be able to receive this ACK/NACK, as UE would send the ACK/NACK by old beam since the PDCCH is missed but gNB would receive it by new beam. So we think the beam mismatch for ACK/NACK would be a problem.  Moreover, unified TCI would be used for inter-cell mobility as well. If RAN2 decides to update some RRC parameters after a new TCI indication, the whole link may be broken if gNB starts to use new RRC parameters to communicate with UE but UE is still using old parameters. |
| Docomo | Support proposal 3.1. Support Alt. 1. We think it is useful if there is no DL data.  For BAT, support Alt. 2 to avoid misunderstanding between gNB and UE. It is true that very long application time can be configured in Alt. 1, and if gNB has no ACK reception, gNB can re-send another DCI to update the beam. However, this gNB implementation is the same as Alt.2.  {Mod: Not quite, since with Alt2, X/Y > 0, which implies that the advantage of Alt1 for DL assignment/PDSCH being able to use the updated TCI state is never feasible with Alt2 – unless X/Y < 0 ☺.} |
| Nokia/NSB | Support proposal 3.1. Support Alt 1.  For BAT, we support Alt 2. But open for faster PDSCH/PUSCH beam indication. |
| Samsung | Support proposal 3.1, with a slight preference to Alt2 over Alt1. Do not support Alt0.  For BAT, we support Alt1 (i.e. from the DCI containing the TCI state) for the reasons mentioned by the FL. |
| CATT | Proposal 3.1: Support alt-0 and alt-1. The need of alt-2 is not strong.  Proposal 3.2 (BAT): Slightly prefer alt-1 due to reasons articulated by the moderator. Alt-2 is acceptable though. |
| Qualcomm | For Proposal 3.1, suggest to use same wording as Alt1 for acknowledgement examples in Alt2. For the DCI format, we also support at least DCI 0\_1 and 0\_2 for more flexibility   * Alt2: Dedicated DCI format other than 1\_1/1\_2 without DL assignment, applicable for joint TCI as well as separate DL/UL TCI   + Support DCI acknowledgment mechanism, e.g. based on SPS PDSCH release, based on triggered SRS, based on DCI indicating SCell dormancy   For Proposal 3.2, we are fine for either modified Alt.1 or Alt.2 below. If we allow gNB to configure application time before the acknowledgement, there can be a beam misalignment period from the application time to the acknowledgement. Suggest to avoid this configuration.   * + Alt1: the first slot that is at least X ms or Y symbols after the DCI with the joint or separate DL/UL beam indication     - The gNB configured application time should be after the acknowledgement.   + Alt2: the first slot that is at least X ms or Y symbols after the acknowledgment of the joint or separate DL/UL beam indication |
| Futurewei | We support Proposal 3.1 and prefer Alt. 2 |
| Lenovo/MoM | Support proposal 3.1. Do not support Alt0.  Regarding BAT, we support Alt2 mainly to avoid misunderstanding of the TCI between gNB and UE. To address LG’s concern regarding how the TCI applies to PDSCH or PUSCH (or both), we think an channel indicator field can be introduced in the DCI format to signal which channel the TCI applies to. |
| Huawei, HiSilicon (2nd batch) | Proposal 3.1: Perhaps the FFS point in Alt-1 should be ‘not indicating a SPS PDSCH release or indicating SCell dormancy’. At the end of the FFS point in Alt-1, we suggest adding ‘considering impacts on PDCCH coverage and scheduling mechanism’. We also suggest putting ‘based on SPS PDSCH release’ in the first sub-bullet of Alt-2 as an example, similar as Atl-1.  BAT: Proponents of Alt-1 acknowledged the possibility of gNB/UE beam misalignment with Alt-1, but argued that it happens only during short periods, will not happen to channels carrying beam indication DCI, and can be avoided by gNB implementation (configuring BAT after ACK). We are not convinced by these arguments: 1. Even if the time period is short, once beam misalignment happens, the consequence is significant; 2. Beam misalignment may also happen to channels carrying beam indication DCI, and limiting to the case where beam indication DCI is transmitted over common CORESETs only is overly restrictive; 3. If the configured BAT is after ACK (as suggested by QC, which mandates gNB configuration), the expected latency advantage of Alt-1 over Alt-2 is gone, while gNB/UE still needs to live with complexities raised from allowed configurations.  {Mod: Thank you, this is the type of counter-argument against Alt1 proponents I was looking for! Also acknowledged by the moderator. If Alt1 proponents can respond, it will be appreciated.} |
| Moderator | Proposal 3.1 is relatively stable now.  A proposal on BAT will be included in round 3. |
| ZTE | Proposal 3.1: Support |
| MediaTek | Support Proposal 3.1 |
| Moderator | Proposal 3.1 is quite stable. |
| InterDigital | We are fine with the proposal and support Alt1. |
| NEC | Support the FL proposal. |
| Qualcomm | For Proposal 3.1, suggest to also add the following FFS to Alt2  FFS: Whether the UE can/shall assume the gNB configured application time is after ACK transmission  {Mod: done} |
| ZTE | Support the FL proposal |
| Xiaomi | As for Proposal 3.1, we share same view as LG. we also suggest to add DCI format 0\_1/0\_2 as Alt 3. If not, two DCIs are needed to schedule PUSCH with one for UL TCI state and the other one for resource allocation.  As for BAT, we prefer Alt 1 since Alt 1 can cover Alt 2 as explained by FL. |

### Issue 4 (MP-UE)

Table 7 Summary: issue 4

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 4.3 | Support for NW-initiated UL panel selection and activation | NW-initiated UL panel selection (of one) and activation (of ≥1)   * **Yes**: IDC, Huawei/HiSi, ZTE, LGE, NTT Docomo,CMCC * **No**: OPPO, Fraunhofer IIS/HHI, CATT, MTK, Intel, Sony, Xiaomi, Qualcomm (NW can initiate selection within active panels but not activation), Spreadtrum, Nokia/NSB   NW-to-MPUE signaling of panel selection/activation:   * **Yes**: NTT Docomo, Lenovo/MoM, Xiaomi, APT, IDC (panel ID in TCI state), Samsung (in case of MPE), CATT, APT, vivo, Qualcomm (NW can signal which active panel to use but not activation), Spreadtrum (select among active panels), Nokia/NSB, Huawei/HiSi (with UE confirmation/rejection), LG, CMCC * **No**: OPPO | |

In RAN1#103-e, the support for UE-initiated UL panel selection/activation was agreed, with FFS on whether NW-initiated panel selection/activation is also supported. This FFS needs to be resolved early.

Based on the above summary, the following proposals are made:

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| **For discussion**  {Original formulation; selection and activation: Alt1}  **Proposal 4.1**: On Rel.17 enhancement for facilitating fast uplink panel selection, support NW-to-MPUE signalling to facilitate UE panel selection and activation:   * For UE panel selection, Rel.17 DCI-based TCI state update (beam indication) is used * For UE panel activation and selection, Rel.17 MAC-CE-based TCI state activation is used * FFS: If additional specification support in TCI state definition to associate with UE panel is needed or not, and if so, the exact scheme * FFS: If additional specification support to let gNB aware which UE panel is used is needed or not, and if so, the exact scheme * FFS: if additional specification support is needed for UE-initiated panel activation and NW-initiated panel activation to work together * FFS: Linking or association of UE panels with CSI-RS and/or SRS resource sets   **Support (9)**: ZTE, vivo, Convida, Lenovo/MoM, Ericsson, LG, CATT, NTT Docomo  **Not support (8)**: MTK, OPPO, Sony, Nokia/NSB, Qualcomm, Intel, Xiaomi  {Nokia/NSB/Qualcomm’s formulation; only selection, no activation: Alt2}  **Proposal 4.1**: On Rel.17 enhancement for facilitating fast uplink panel selection, Rel-17 unified TCI framework (including TCI state update along with the necessary TCI state activation) is used for UE panel selection:   * Additional dynamic NW-to-MPUE signalling of UE panel selection or activation is not supported * FFS: Whether to support gNB requesting the UE to activate more UE panels utilizing signals for Rel.17 TCI configuration/activation. * FFS: If additional specification support in TCI state definition to accommodate UE panel is needed or not, and if so, the exact scheme * FFS: Linking or association of UE panels with CSI-RS and/or SRS resource sets   **Support (7)**: Nokia/NSB, Qualcomm, Xiaomi, Huawei/HiSi  **Not support**: MTK |

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| Action: Interested companies are encouraged to provide their inputs on the two versions ALT1 and ALT2 (which one they support and why) and/or propose refinement on the text  Goal: Finalize the proposal to be ready for endorsement |

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| **Revised Proposal 4.1**: On Rel.17 enhancement for facilitating fast uplink panel selection,   * Rel.17 TCI state update (based on MAC CE + DCI, along with the necessary TCI state activation) is used for UE panel selection:   + FFS: If additional specification support in TCI state definition to accommodate UE panel is needed or not, and if so, the exact scheme   + FFS: UE panel-specific report, including UE-panel state, e.g. inactive, active for DL/UL measurement, active for UL transmission, or active for both DL/UL measurement and UL transmission * FFS: Support for NW-initiated UE panel activation * FFS: UE panel-specific report, including UE-panel state of: inactive, active for DL/UL measurement (i.e., panel activation), or active for UL transmission (i.e., panel selection) * FFS: Linking or association of UE panels with CSI-RS and/or SRS resource sets |

Table 8 Inputs: issue 4

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| **Company** | **Input** |
| Moderator | 4.1: This proposal is to ensure that there is beam indication support. The FFS addresses additional TCI state definition for panel. This also depends on what panel entails. Agreeing to this proposal doesn’t imply that we agree on a new TCI state signaling scheme. Similar to the previous agreement on UE-initiated panel selection/activation. |
| Apple | Without beam reporting enhancement like option 1 in item 2c, we do not know how gNB can make the decision for panel selection. |
| MediaTek | We still don’t see any benefit from both NW-initiated/assisted panel activation and selection according to the comments from previous round discussion. We agree with ZTE that it is good to have a proposal to clarify how the system can work in this UE-initialized framework. We believe Rel-17 unified TCI framework (including switching between separate DL/UL TCI update and joint DL/UL TCI) can already provide the signaling to “confirm” the UL panel selection initialized by UE. Regarding gNB request to activate more UE panels, we can further study it. Suggest the following update to Alt2 proposal:  **Proposal 4.1**: On Rel.17 enhancement for facilitating fast uplink panel selection, Rel-17 unified TCI framework (including TCI state update along with the necessary TCI state activation)is used for confirming the UL panel selection initiated by UE:   * Additional dynamic NW-to-MPUE signalling of UE panel selection or activation is not supported * FFS: Whether to support gNB may request UE to activate more UE panels utilizing signals for Rel.17 TCI configuration/activation. * FFS: If additional specification support in TCI state definition to accommodate UE panel is needed or not, and if so, the exact scheme   {Mod: From Nokia’ response and my understanding of the agreement, UE-initiated can imply recommendation. So the gNB-to-UE signaling may not be confirmation, but actually (group-)beam indication. The confirmation scheme is separate.} |
| Docomo | We support Alt.1. We think NW initiated panel selection is useful in UL interference management which is one of the use cases of panel selection identified in last meeting. With NW initiated panel selection, NW can indicate panel for UL Tx with less UL interference based on UL interference measurement. |
| Nokia/NSB | Support Nokia’s version captured above. But we welcome any kind explanation how (based on which reporting/measurement) gNB can decide to activate UE panel.  As response to MediaTek’s commend, I do not understand how UE can select it’s panel, when gNB indicates certain bean/TCI to be used for UL and if that certain beam can only be transmitted by only one of the activated UE panel. It could be up to UE how to associate/perform measurement configuration with each UE panel, but once TCI is indicated, UE would not be able to ‘change’ the panel. I hope the 1st sub-bullet would clarify that UE panel can be transparent at gNB. |
| Samsung | We sympathize with the companies that want to keep panel related information (including activation and selection) as an implementation detail within the UE. However, it might be good to study the benefit and feasibility of network signaling to assist with UE panel selection. The network awareness of the UE panels might be explicit or implicit. So in general we are supportive of this proposal.  We would like to add the following FFS:  FFS: Linking or association of UE panels with CSI-RS and/or SRS resource sets. |
| CATT | Support alt-1. |
| Qualcomm | Support Alt2. As explained multiple times, UE determines panel activation based on many factors including power consumption considerations, which cannot be known by gNB completely and timely. We have no issue for gNB to select among active panels. We are also fine for gNB to request UE to activate panels with final decision made by UE. |
| Lenovo/MoM | Support Alt1. We think it is beneficial for NW initiated panel activation and selection for UL interference management. Since a panel is already defined as a set of antenna ports, details of UE implantation can be embedded in the antenna ports, leaving a panel only as logic concept without touching UE implementation details. |
| Huawei, HiSilicon | The current formulation of Alt-2 seems to imply that MAC-CE cannot be used for UE panel selection, which is different from previous agreement that when only one TCI state is indicated by MAC-CE, it will be applied directly. We suggest the following update (adding MAC-CE in the main bullet and remove the 1st sub-bullet).  **Proposal 4.1**: On Rel.17 enhancement for facilitating fast uplink panel selection, Rel.17 MAC-CE-based and DCI-based TCI state update (beam indication) is used for UE panel selection:   * ~~Additional dynamic NW-to-MPUE signalling of UE panel selection or activation is not supported~~ * FFS: gNB may request to activate more UE panels utilizing signals for Rel.17 TCI configuration/activation. * FFS: If additional specification support in TCI state definition to accommodate UE panel is needed or not, and if so, the exact scheme   {FFS: This is toward the middle ground – see revised proposal 4.1} |
| Moderator | Proposal 4.1 is revised based on companies views of ALT1 (NW-based activation + selection) vs ALT2 (NW-based selection) |
| ZTE | Regarding 2nd FFS part, it is a little bit weird of gNB request of activating UE panel, and in our views, alternatively, we should allow the panel-specific report of UE panel states (e.g., inactive, active for DL/UL measurement (corresponding to the agreed panel activation), or active for UL transmission (corresponding to the agreed panel selection)). Based on this information, the gNB can well handle DL/UL operation.  **Conclusion 4.1**: On Rel.17 enhancements to facilitate UL beam selection for MP-UE, the following terms are used at least for the purpose of discussion:   * ‘Panel activation’ (at least for DL/UL measurement): activating L out of P available UE panel(s) at least for the purpose of DL and UL beam measurements (e.g. reception of DL measurement RS, transmission of SRS) * ‘Panel selection’ (for UL transmission): selecting 1 out of L activated UE panel(s) for the purpose of UL transmission * Note: UE-initiated panel activation and selection have been agreed in RAN1#103-e   Therefore, we have the following update.  **Revised Proposal 4.1**: On Rel.17 enhancement for facilitating fast uplink panel selection, Rel.17 TCI state update (based on MAC CE + DCI, along with the necessary TCI state activation) is used for UE panel selection:   * FFS: Support for NW-initiated UE panel activation * FFS: UE panel-specific report, including UE-panel state of: inactive, active for DL/UL measurement (i.e., panel activation), or active for UL transmission (i.e., panel selection) * FFS: Whether to support gNB requesting the UE to activate more UE panels utilizing signals for Rel.17 TCI configuration/activation. * FFS: If additional specification support in TCI state definition to accommodate UE panel is needed or not, and if so, the exact scheme * FFS: Linking or association of UE panels with CSI-RS and/or SRS resource sets   {Mod: Yes, sir ☺ added, that’s consistent with the previous agreement} |
| MediaTek | Re Nokia, you mean UE is not able to select its own UE panel in Rel-15/16. Now, in Rel-17, NW has to teach UE how do that. In Rel-15/16, TCI activation and indication only inform UE what is the “gNB” beam(s) is used for DL reception, instead of “UE” beam(s). How to associate between UE beam/panel and TCI state is up to UE decision. When UE movies or rotates, UE can change its beam(s) or panel(s) corresponding to the active TCI state(s), without NW’s “permission”.  According to Nokia’ response, we now are worry about that these proposals may mandate UE always to use a certain panel selected by NW. Thus, we cannot support these proposals.  {Mod: If beam indication is used, yes, the UE has to follow what the gNB dictates. But please check my comment below. Perhaps some clarification can be added to make Proposal 4.1 agreeable.} |
| Moderator | @Bo/Darcy: The intention of this proposal is to enable beam-indication-based UL panel selection (1 out of L). Since NW-initiated panel activation is still FFS and we have agreed to support UE-initiated panel selection (1 out of L) and activation (L out of P), proposal 4.1 combined with the previous agreement allows at least:  - UE-initiated panel activation and beam-indication-based (NW-initiated) panel selection  - UE-initiated panel activation and selection, and beam-indication-based (NW-initiated) panel selection (this could serve as a confirmation mechanism?)  Agreement:  In Rel.17 enhancement for facilitating fast uplink panel selection, UE-initiated UL panel selection/activation are supported:   * FFS: Whether NW-initiated panel selection/activation is also supported * FFS: Whether specification support for this feature is necessary and if so the details of such spec support. |
| InterDigital | We support the proposal |
| NEC | Support the FL proposal. |
| OPPO | Do not support Proposal 4.1  The wording seems to imply that some information “panel ID” will be signaled through rel17 TCI state update for UE panel selection.  As we have explained a few time, how to select panel and which panel(s) are selected is UE implementation. The UE might choose different strategy to select panels according each parituclar requirement, it could be due to MPE issue. It could be due to transmission issue, or even hardware issue. In the signaling, the system only indicate TCI state to the UE and the UE chooses proper Tx beam and/or panel accordingly.  {Mod: Agree, the proposal doesn’t imply that an additional spec feature will be supported. It simply means that beam indication based UE panel selection is supported. It is possibly without spec impact, similar to our previous agreement on UE-initiated approach. I have reorganized the proposal (please check) and hope this clarifies the intention.} |
| Qualcomm | For revised Proposal 4.1, suggest to make the active/inactive states as the examples in the revised bullet below, since 2 active/inactive states may be enough with “active” defined as for both DL/UL measurement and UL transmission. To our understanding, some kind of measurement has to be performed for a panel to be used for UL transmission, as in R15/16. In addition, suggest to remove the two brackets “(i.e., panel activation)” and “(i.e., panel selection)”, since they are all for panel selection and have already been activated to our understanding, i.e. measurement can only be done within those active panels for panel selection purpose.  FFS: UE panel-specific report, including UE-panel state, e.g. inactive, active for DL/UL measurement, active for UL transmission, or active for both DL/UL measurement and UL transmission  {Mod: done} |
| ZTE | Support the FL proposal. QC’s suggestion looks good to us. |
| Xiaomi | We prefer Alt 2. We think panel activation is an UE implementation issue. And gNB can select panel via TCI state indication after beam measurement.  Support the revised proposal 4.1. |

### Issue 5 (MPE mitigation)

Table 9 Summary: issue 5

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| **#** | **Issue** | **Companies’ views** | **Moderator notes** |
| 5.3 | Any additional reporting content:   * Alt0: no additional reporting content * Alt1: Additional reporting content | **Alt0**: Ericsson, Intel, Xiaomi, MTK, Spreadtrum, Lenovo/MoM, Huawei/HiSi, APT  **Alt1**:   * CRI/SSBRI + L1-RSRP/L1-SINR + P-MPR: OPPO, MediaTek, Nokia/NSB, IDC * CRI/SSBRI + L1-RSRP/L1-SINR + virtual PHR: Nokia/NSB, Apple, Convida, CMCC * CRI/SSBRI + L1-RSRP/L1-SINR + panel ID: LG, CMCC * CRI/SSBRI + virtual PHR: ZTE, Convida * CRI/SSBRI + UL RSRP + panel ID: Qualcomm * CRI/SSBRI + new/additional param. (indicating MPE): CMCC * P-MPR + panel-ID: vivo, Sony (panel-specific), IDC * P-MPR + alternative panel or UL TX beam: Nokia/NSB * ID of preferred/non-preferred panel: LGE | |

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| **Previous agreements**:  [RAN1#103-e]  On UE reporting for MPE mitigation for Rel-17, investigate and, if needed, specify the following:   * … * Any additional reporting content: down-select from the following in RAN1#104-e   + Alt0: no additional reporting content   + Alt1: Additional reporting content is included (for example P-MPR + L1-RSRP, virtual PHR + L1-RSRP, L1-RSRP/SINR with and without MPE effect, virtual PHR, P-MPR or virtual PHR + CRI/SSBRI, estimated max UL RSRP)     - Note: Other options are not precluded     - FFS: Whether the above reporting is triggered by UE or configured by NW   [RAN1#104-e]  On Rel.17 enhancements to facilitate MPE mitigation,   * On further enhancing the P-MPR report in Rel.16 (already agreed RAN4 framework, including triggering), down select between beam-level and panel-select reporting * On SSBRI(s)/CRI(s) and/or indication of panel selection, focus study on the following:   + Reporting of at least SSBRI(s)/CRI(s) to indicate gNB beam(s) that is feasible for UL transmission: additional reporting quantities are FFS   + Reporting of at least an indicator associated with a UE ‘panel’ that is feasible for UL transmission: additional reporting quantities are FFS * Note: Just as agreed in RAN1#103-e, the purpose is to assess whether specification is needed or not |

It was agreed that we have to down-select the alternatives for additional reporting content in this meeting. From the summary, L1-RSRP/SINR and virtual PHR are the quantities supported by more companies.

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| **Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation:   * Decide in RAN1#104bis-e whether the following combinations should be further studied (not necessarily, but can be, in one reporting instance):   + {Rel.16 P-MPR based (beam/panel-level)} + {A}, where A is either Opt 2 or Opt3   + {SSBRI(s)/CRI(s) and/or panel indication} + {A}, where A is either Opt1 or Opt2 or both * Option 1: L1-RSRP [L1-SINR] associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured)   + FFS: How panel-level L1-RSRP [L1-SINR] is calculated if L1-RSRP [L1-SINR] is associated with panel   + FFS: Whether/how to include MPE effect in L1-RSRP [L1-SINR)   + FFS: Whether/how to enhance existing beam reporting format to support Option 1 * Option 2: Virtual PHR or a modified version associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) * Option 3: Virtual PHR or a modified version associated with each activated UL TCI or, if applicable, joint TCI |

**Support**: Apple, MTK, ZTE, OPPO, Sony, Nokia/NSB, Convida, Lenovo/MoM, Qualcomm, [Intel], APT, LG, Xiaomi, CATT

**Not support**: vivo, Ericsson, Huawei/HiSi,

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| Action: Interested companies are encouraged to provide their inputs on the proposal  Goal: Finalize the proposal to be ready for endorsement |

Table 10 Inputs: issue 5

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| **Company** | **Input** |
| Moderator | 5.1: Latest version form round 2, please keep in mind this is for “perform study and, if needed, specify”.  Re comment on down selecting between beam vs panel, please check the round-0 summary to see if that’s indeed possible. And remember we had an agreement to down select next meeting for study purpose.  The group has not AGREED to support any new spec feature for Rel.18 MPE mitigation yet. But we should start deciding soon. |
| Apple | Support the proposal. |
| MediaTek | Support the proposal but prefer study and specify in Rel-17 instead of Rel-18 ☺. |
| Docomo | * First we would like to clarify whether the additional reporting quantity is based on Rel-16 PMPR report framework, or L1 beam reporting framework. We think whether and what additional report quantity is needed is related to which report framework is used.   {Mod: For the purpose of study, both are already agreed in last meeting, also clarified in 5.1 of round 2, and again clarified above in the Notes}   * We also would like to clarify how L1-RSRP/SINR is associated with a panel, since in our understanding, L1-RSRP/SINR is measured per beam.   {Mod: I’ll let the proponents explain but I can add FFS.This is a good point.} |
| Nokia/NSB | Support in principle |
| Samsung | Support in principle, but we have some clarifications:  For option 1: Rel-15/16 already supports L1-RSRP/L1-SINR reporting per beam. It would seem that a new aspect to consider, can be how to include the MPE-effect in the measurement report to assist the network in selecting a new beam.  We would like to add the following FFS to Option 1: FSS: How to include MPE effect in L1-RSRP/L1-SINR  {Mod: Done, added “whether/how”}  The combinations listed in the note are not clear, for example the reporting of A should always include an SSBRI/CRI/panel ID in this case the difference between first and third combination is not clear.  {Mod: Good point. I removed the 3rd combination.} |
| vivo | Not support the three combinations. Still think we should focus study on already agreed Rel.16 based P-MPR and SSBRI(s)/CRI(s)/panel indication.  The two clarification questions from Docomo is also helpful.  {Mod: I changed the proposal to set the deadline for the next meeting to give the proponents a chance to make their case. If there is no consensus, we will focus on Rel.16 P-MPR-based and SSBRI(s)/CRI(s)-based only. I hope this is fine.} |
| Qualcomm | Suggest to modify Option 2 a bit. To our understanding, current virtual PHR may not consider the P-MPR info. If the P-MPR is considered in virtual PHR, then additional reporting of P-MPR can be saved.   * Option 2: Virtual PHR or modified version associated with each of the reported SSBRI(s)/CRI(s)/panel indication (if configured) or for each activated UL or joint TCI |
| Lenovo/MoM | Support in principle |
| Huawei, HiSilicon | The formulation is getting difficult to follow. First we share similar questions as DOCOMO. Second, it appears Option 1/2 are related to SSBRI/CRI reporting, but not P-MPR reporting. If the proposal is to study options listed in the 3rd bullet, we suggest promoting the 3rd bullet as the 1st bullet, and demote the existing 1st and 2nd bullets as subsequent explanations. We also suggest clarifying that ‘Rel.16 P-MPR based’ includes panel/beam-level P-MPR reporting that is being discussed in Rel-17.  {Agreed, done} |
| Moderator | The format of proposal 5.1 is changed per Huawei’s suggestion and the 3rd combination is removed (not needed). |
| ZTE | Proposal 5.1: Support |
| MediaTek | 1. Since SSRI(s)/CRI(s) and panel indication may or may not be supported as a combination, it would be better to add “and/or” between them.   {Mod: OK, we haven’t excluded having both}   1. Regarding Opt2, according to the comments and proposals from companies, virtual PHR associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) is considered as a candidate when {SSBRI(s)/CRI(s) and/or /panel indication} is reported. Virtual PHR associated with each TCI is considered as a candidate when Rel.16-based P-MPR report is used. Thus, we prefer to separate them into two options as follow:  * Option 1: L1-RSRP/SINR associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) * Option 2: Virtual PHR or a modified version associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) * Option 3: Virtual PHR or a modified version associated with each activated UL TCI or, if applicable, joint TCI   We also would like to clarify possible combinations accordingly. To our understanding, {Rel.16-based P-MPR reporting} and {SSBRI(s)/CRI(s) and/or panel indication} would be two separate reporting formats. Since {Rel.16-based P-MPR reporting} doesn’t provide {SSBRI(s)/CRI(s) and/or /panel indication}, it is unlike to combine it with Option 1 or Option 2. Combination of {SSBRI(s)/CRI(s) and/or /panel indication} and Option 3 is also not reasonable. Thus, we suggest the following update:   * + {Rel.16 P-MPR based (beam/panel-level)} + Opt3   + {SSBRI(s)/CRI(s) and/or panel indication} + {A}, where A is either Opt1 or Opt2 or both   {Mod: I tend to agree}   1. Regarding the last bullet, it seems the 3rd bullet is promoted as the 1st bullet, thus it can be deleted. 2. Re DoCoMo, to our understanding, {SSBRI(s)/CRI(s) and/or panel indication}+Opt1 is pretty much similar to existing beam reporting, thus it is possible to enhance existing beam reporting format. However, this can be further discussed. We suggest to add one FFS under Option 1 for this studying.   o FFS: Whether/how to enhance existing beam reporting format to support Option 1  In summary, we provide the following update as reference.  **Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation,:   * Decide in RAN1#104bis-e whether the following combinations should be further studied (not necessarily, but can be, in one reporting instance):   + {Rel.16 P-MPR based (beam/panel-level)} + Opt3   + {SSBRI(s)/CRI(s) and/or panel indication} + {A}, where A is either Opt1 or Opt2 or both * Option 1: L1-RSRP/SINR associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured)   + FFS: How panel-level L1-RSRP/SINR is calculated if L1-RSRP/SINR is associated with panel   + FFS: Whether/how to include MPE effect in L1-RSRP/L1-SINR   + FFS: Whether/how to enhance existing beam reporting format to support Option 1 * Option 2: Virtual PHR or a modified version associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) * Option 3: Virtual PHR or a modified version associated with each activated UL TCI or, if applicable, joint TCI   {Mod: Thanks, I see the suggested changes give better clarity in content and scope.} |
| Moderator | Refined proposal 5.1 according to the comments from Darcy. Please check. |
| NEC | Support the FL proposal. |
| Apple | For option 1, we suggest we add a bracket for “/SINR’, we think L1-SINR is more helpful for DL beam selection, but not quite useful for UL beam selection.  {Mod: Done, square brackets are added.} |
| Qualcomm | Support the Proposal 5.1 |
| ZTE | We are fine to further split the original Option-2 into new Option 2 and new Option 3 as Darcy suggested. But, after reconsidering, besides new Option-3, we think that the new Option-2 can also be considered in “{Rel.16 P-MPR based (beam/panel-level)}”. Compared with new Option-3, the gNB can provide a candidate RS list (rather than activated TCI state), and then the UE select one or more of the list and report them in the {Rel.16 P-MPR based (beam/panel-level)}. Therefore we have the minor update, and hopefully it can be fine with other companies.   * Decide in RAN1#104bis-e whether the following combinations should be further studied (not necessarily, but can be, in one reporting instance):   + {Rel.16 P-MPR based (beam/panel-level)} + {A}, where A is either Opt 2 or Opt3   + {SSBRI(s)/CRI(s) and/or panel indication} + {A}, where A is either Opt1 or Opt2 or both   {Mod: Done} |
| Xiaomi | Support proposal 5.1. |

### Issue 6 (beam refinement/tracking)

This is the status after the second GTW (online) session 01/29/2021.

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| **Possible Agreement**  On Rel.17 enhancements based on the unified TCI framework, perform study and, if needed, specify the following:   * Beam management with reduced DL signaling to reduce latency * Reducing activation delay of TCI states and PL-RSs (including other WGs, e.g. RAN4)   + On RAN4-related matters, assessment/study phase can be done in RAN1. If RAN4-based enhancements are found necessary, a LS to RAN4 will be sent (to prepare RAN4 work)   Note: Given its dependence on the maturity of and lower priority compared to other issues (1 to 5), when to start the work and how much work is done on issue 6 should depend on the progress on the other issues.  **Objected by** Huawei/HiSi  **Support by** Futurewei (clarify 2nd bullet), MTK, Samsung, OPPO, Apple, Intel, NTT Docomo, Qualcomm (clarify 2nd bullet), Ericsson, IDC, Spreadtrum (after other issues progress enough), Xiaomi, Nokia/NSB (clarify 2nd bullet), Convida (after other issues progress enough), Lenovo/MoM, CATT, ZTE, NEC |