**3GPP TSG RAN WG1 #106-e R1-2108325**

**e-Meeting, August 16th – 27th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#2 for multi-beam enhancement: ROUND 1

**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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| 1. Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:    1. Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management for intra-cell and inter-cell scenarios to support higher UE speed 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)       4. For inter-cell beam management, a UE can transmit to or receive from only a single cell (i.e. serving cell does not change when beam selection is done). This includes L1-only measurement/reporting (i.e. no L3 impact) and beam indication associated with cell(s) with any Physical Cell ID(s)          1. The beam indication is based on Rel-17 unified TCI framework          2. The same beam measurement/reporting mechanism will be reused for inter-cell mTRP          3. This work shall only consider intra-DU and intra-frequency cases    2. 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 |

This summary includes the following:

* Observation and proposal
* Summary of current companies’ positions on each of the aspects within the category

## Summary of companies’ inputs

The listed issues are structured primarily to facilitate some progress on pending issues identified in the agreements (see Appendix A).

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

Table 1 Summary: issue 1 (from round 0 inputs)

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| **Proposal** | **Companies’ views** |
| 1.B-1 (CSI-RS target RS DL) | **Support**: MTK, Qualcomm, Sony, FGI/APT, Ericsson, Fraunhofer IIS/HHI, Samsung, LG, Xiaomi, ZTE, Convida, CATT, Spreadtrum, Nokia/NSB, AT&T, Intel, NTT Docomo, Lenovo/MotM  **Not support**: Huawei/HiSi, vivo (ok if trigger offset restriction is added), Futurewei, |
| 1.B-2 (target SRS) | **Support**: MTK, Qualcomm, NTT Docomo, Sony, FGI/APT, Ericsson, Fraunhofer IIS/HHI, Samsung, Xiaomi, LG, ZTE, Convida, CATT, Spreadtrum, AT&T, Intel, NTT Docomo,  **Not support**: Huawei/HiSi, Futurewei, Nokia/NSB |
| 1.B-3 (non-dedicated DL DMRS as target RS) | **Support**: MTK, Qualcomm, Sony, FGI/APT, Ericsson, Fraunhofer IIS/HHI, Samsung, LG, Xiaomi, ZTE, Convida, CATT, Spreadtrum, Nokia/NSB, AT&T, NTT Docomo  **Not support**: Lenovo/MotM, Intel, Huawei/HiSi, vivo, Futurewei, |
| 1.C (beam indication) | **Support**: MTK, Qualcomm, NTT Docomo, Sony, FGI/APT, Ericsson, Fraunhofer IIS/HHI, Samsung, Xiaomi, ZTE, Convida, Spreadtrum, Nokia/NSB, AT&T, Intel, NTT Docomo,  **Not support**: Apple (wait until 1.B is concluded), Lenovo/MotM, CATT, vivo, Futurewei, |
| 1.D (beam alignment) – from Chairman notes V5 | **Only need wording refinement** |
| 1.E (UL PC for SRS) | **Support**: Apple, MTK, Qualcomm, Lenovo/MotM, NTT Docomo, FGI/APT, Ericsson, Samsung, Intel, ZTE, Convida, CATT, vivo, Futurewei, Spreadtrum, AT&T, NTT Docomo,  **Not support**: OPPO, |
| 1.F (M,N>1) | **Support**: Qualcomm, Lenovo/MotM, FGI/APT, Samsung, ZTE, IDC, CATT, vivo, Futurewei, Lenovo/MotM, AT&T,  **Not support**: NTT Docomo, Ericsson, Fraunhofer IIS/HHI, Intel, Convida, MTK, Apple (ok mTRP, not ok sTRP), Spreadtrum (use cases shouldn’t be FFS), OPPO (finalize use case first), Xiaomi, CMCC, Sony |

**Proposal 1.B-1**: On Rel.17 unified TCI framework, the following DL RSs can share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC

* Aperiodic CSI-RS resources for CSI [at least when the triggering offset is smaller than within *beamSwitchTiming*]
* Aperiodic CSI-RS resources for BM [at least when the triggering offset is smaller than within *beamSwitchTiming*]
  + FFS: Discuss if further restriction is necessary, e.g. only for repetition ‘ON’, apply to all resources in a set
* FFS: Other CSI-RS time-domain behaviors and/or restriction(s)

**Proposal 1.B-2**: On Rel.17 unified TCI framework:

* Some SRS resources or resource sets for BM can share the same indicated Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC
  + FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic, apply to all resources in a set
  + Note: This doesn’t imply that all time-domain behaviors are automatically supported

**Proposal 1.B-3**: On Rel.17 unified TCI framework, the following DL RSs can share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC:

* DMRS(s) associated with non-UE-dedicated reception on CORESET(s) and the associated PDSCH, if the CORESET(s) is associated any USS set

**Proposal 1.C**: On Rel.17 unified TCI framework, for any DL RS that does not share the same indicated Rel-17 TCI state(s) as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC, but can be configured as a target DL RS of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool), Rel-15/16 TCI state update signaling/configuration mechanism(s) are reused to update/configure the Rel-17 TCI state.

**Proposal 1.D (from Chairman notes v5)**: On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes:

* “Beam alignment” is defined as follows:
  + The event that the PL-RS is identical to the spatial relation RS in the UL or (if applicable) joint TCI state.
  + FFS: how to define “beam alignment” if the PL-RS and the spatial relation RS in the UL or (if applicable) joint TCI state are not identical
* Any other case, there is no beam alignment

**Proposal 1.E**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, the setting of (P0, alpha, closed loop index) for SRS can also be associated with UL or (if applicable) joint TCI state.

* If not associated, the setting(s) of (P0, alpha, closed loop index) for SRS per BWP is independent of the UL or (if applicable) joint TCI states
* This is only applicable for SRS sets using Rel-17 TCI state to determine their spatial relation.

FFS: Whether more than one parameter sets can be configured, e.g. for different traffics

**Proposal 1.F**: On Rel-17 unified TCI, in addition to (M,N)=(1,1), the following combinations are supported: (M,N)=(2,1), (1,2), and (2,2) for mTRP and some sTRP use cases

* Note: At least in Rel-17, the support of N=2 does not imply the support of STxMP
* FFS: Which sTRP use case(s) and other use case(s), e.g. CORESET beam diversity, inter-cell beam management, MP-UE, inter-band CA
  + Strive unified signaling to support sTRP use case(s)
* FFS: How to support M>1 and/or N>1, e.g., association between a Rel-17 unified TCI state code point with a group of beams, or multiple channel/RS types are flexibly grouped to apply a same Rel-17 TCI state

Table 2 Additional inputs: issue 1

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 1**  **2) Share your inputs on the above FL proposals**  **3) Proponents of 1.B-1/2: please respond to Huawei’s inquiry:**  [Huawei] “We are still not sure if this is a good direction to go. For periodic CSI-RS, its QCL should not follow PDCCH/PDSCH; and for aperiodic CSI-RS, the behavior of following PDCCH can be achieved with R16 specs. Both have been explained in our previous comment, but no response is received. We are also not a big fan of saying “some” in a potential agreement.”  **4) Proposal 1.D: check the current wording and suggest mods if any** |
| Ericsson | **Proposal 1.B-1:** Essentially support, but it lumps many things together unnecessarily. Reply to Huawei: I can understand the reluctance to agree to “some” – it is somewhat of a blank check. I also understand the comment about periodic CSI-RS. Then, for aperiodic CSI-RS, there is no agreement to support the default behavior as in Rel-16: the “follow PDCCH” is not automatically achieved. It is that exact same behavior that is intended, and to extend to all scheduling offsets: in general it is preferable to have the same behavior for larger scheduling thresholds as well. Could we perhaps formulate it like this instead:  **Proposal 1.B-1**: On Rel.17 unified TCI framework:   * The following DL RSs can share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC   + Aperiodic CSI-RS resources for CSI   + Aperiodic CSI-RS resources for BM   FFS: Other CSI-RS time-domain behaviors  Then, some companies propose that CSI-RS for BM is limited to repetition ‘ON’. I don’t understand why: measurements on the CSI-RS with repetition ‘off’ are also quite valuable, and the Rel-16 “follow PDCCH” is supported also for repetition ‘off’.  We would then take DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs later.  [Mod: Understood. Separated CSI-RS from DM-RS. AP-CSI-RS seems agreeable to supporters. Left the additional restriction in FFS]  Proposal 1.C: Support. It is difficult to see what the alternative would be: the Rel-17 signalling framework would have to be significantly extended to handle other channels.  Proposal 1.D: Support  Proposal 1.E: Support  Proposal 1.F: Do not support to introduce explicit signaling for this purpose.  [Mod: The proposal doesn’t imply any explicit signaling is supported yet. Only M/N=2] |
| Samsung | **Proposal 1.B-1/1.B-2:** Support  We can delete the word “some”. The main bullet says: “The following DL RSs can share the same indicated Rel-17 TCI state as …” This doesn’t imply that all CSI-RS resources for CSI or for BM will share the same indicated Rel-17 TCI state. There can be additional conditions as describe in the FFS.  **Proposal 1.C:** Support  **Proposal 1.D:** Support  There are two conditions for beam alignment, maybe for clarity we can rephrase as follows:  On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, “beam alignment” is defined as follows:   * Beam alignment is defined as:   + the event that the PL-RS is identical to the spatial relation RS in the UL or (if applicable) joint TCI state. If not identical, OR   + ~~beam alignment is defined as~~ the event that the spatial relation RS in the UL or (if applicable) joint TCI state and PL-RS are QCL-ed with respect to TypeD QCL. * Any other case, there is no beam alignment   [Mod: please check revised version]  **Proposal 1.E:** Support  **Proposal 1.F:** Supportive.  We would like to clarify the last FFS: “How to support M>1 and/or N>1, e.g., association between a Rel-17 unified TCI state with a group of beams”, is the intention to redefine a TCI state to provide more than one beam (e.g. have more than QCL Type-D source RS). Alternatively, we can have an association between a TCI state code point and a group of beams, the TCI state code point has more than one TCI state. If the latter, we can say: “FFS: How to support M>1 and/or N>1, e.g., association between a Rel-17 unified TCI state code point with a group of beams”  [Mod: done] |
| Qualcomm | For Proposal 1.B-1: Support  For Proposal 1.B-2: Support  For Proposal 1.C: Support  For Proposal 1.D, we suggest to make the 2nd event more concrete, since clear capability definition will help implementation. Specifically, whether the 2nd event implies the following two cases. We are also open to other cases where the Rx beam of PL RS is identical to the Tx beam indicated by TCI. But each case should be clearly defined. To save the RAN1 time, we are also fine to further clarify the definition of the 2nd event in UE capability.  Case 1: Spatial relation RS is the QCL-TypeD source of the PL RS  Case 2: PL RS is the QCL-TypeD source of the spatial relation  **Proposal 1.D (from Chairman notes v5)**: On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, “beam alignment” is defined as follows:   * Beam alignment is defined as the event that the PL-RS is identical to the spatial relation RS in the UL or (if applicable) joint TCI state. If not identical, beam alignment is defined as the event that the spatial relation RS in the UL or (if applicable) joint TCI state and PL-RS are QCL-ed with respect to TypeD QCL.   + Note: Detailed cases for the 2nd event can be further discussed in UE capability * Any other case, there is no beam alignment   [Mod: please check latest version]  For Proposal 1.E, support  For Proposal 1.F, suggest to add CORESET beam diversity in the list. We think unified TCI should not provide worse reliability than R15. Also, unified signaling should be considered for all sTRP use case(s).  **Proposal 1.F**: On Rel-17 unified TCI, in addition to (M,N)=(1,1), the following combinations are supported: (M,N)=(2,1), (1,2), and (2,2) for mTRP and some sTRP use cases   * Note: At least in Rel-17, the support of N=2 does not imply the support of STxMP * FFS: Which sTRP use case(s) and other use case(s), e.g. CORESET beam diversity, inter-cell beam management, MP-UE, inter-band CA   + Strive unified signaling to support sTRP use case(s) * FFS: How to support M>1 and/or N>1, e.g., association between a Rel-17 unified TCI state with a group of beams   [Mod: Done] |
| Intel | **Proposal 1.B-1**: We are ok remove “Some” from first two sub-bullets. For the DMRS associated with non-UE dedicated reception, our initial comment was not addressed, so we repeat here: which RNTIs are considered for the subset of CORESETs? As mentioned previously, we are still not sure if this work for inter-cell beam management if common signaling is received from the serving cell and UE dedicated PDSCH is received from non-serving cell.  [Mod: Separated DMRS from CSI-RS]  **Proposal 1.D:** Based on online discussion, we just want to clarify that beam alignment is defined only for FR2? In FR1, there is no concept of beam alignment/misalignment?  [Mod: FR2 is the target use case just as the WID says for Item 1 ☺ We may not need to explicitly mention FR1/FR2 just as we usually don’t.]  **Proposal 1.F:** Do not support. We believe that there is plenty of work still to be done to finalize M=N=1 in sTRP and it is better to spend the limited remaining time in Rel-17 to this end. We are ok to consider mTRP and sTRP with M, N>1 in Rel-18. |
| Apple | Proposal 1.C: We still feel this one depends on the outcome of 1.B, if this is for some types of CSI-RS, e.g. periodic CSI-RS, it should be fine to use legacy beam indication approach. But if this is for some common PDCCH/PDSCH, it would be challenging to use Rel-15/Rel-16 beam indication mechanism. Legacy beam indication for PDCCH is per CORESET, but one CORESET can contain both CSS and USS.  Proposal 1.F. We think the use case of mTRP is clear, and we have already discussed quite a lot for mTRP in other AIs. The use case of sTRP is not quite clear to us.  [Mod: Captured] |
| MediaTek | **Proposal 1.B-1 and 1.B-2: Support**  For DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs, according to the agreement made in inter-cell BM, this will not be extended to inter-cell use case. This may address concern from Intel.  We have concern if DMRS(s) associated with non-UE-dedicated reception on all/subset of CORESETs are not allowed for the indicated Rel-17 TCI since one CORESET may need to apply two TCI states according to legacy MAC-CE indication and Rel-17 TCI indication if it is associated with both CSS set and USS set. One compromise solution is, at least allowing non-UE-dedicated PDCCH reception on CORESET(s) and the associated PDSCH, if the CORESET(s) is associated with any USS set.   * DMRS(s) associated with non-UE-dedicated reception on CORESET(s) and the associated PDSCH, if the CORESET(s) is associated any USS set   [Mod: Done. Separated CSI-RS from DMRS]  **Proposal 1.C: Support**  **Proposal 1.D: Support**  **Proposal 1.E: Support**  **Proposal 1.F: Not support,** if Rel-17 cannot focus on mTRP for M, N > 1. |
| NTT Docomo | **Proposal 1.B-1**: We are fine and prefer to remove “some”. We are also OK with Ericsson’s proposal.  **Proposal 1.B-2**: Support.  **Proposal 1.C**: Support. We don’t see any other option.  **Proposal 1.D**: Support the original FL proposal. In Samsung’s updated, we think “OR” is not needed. We agree with Intel, that “beam alignment” is only applicable for FR2, because there is no spatial relation in FR1 in R15/16.  [Mod: Given the source of debate is the case when they are not identical, we first focus on the identical case. Otherwise we cannot progress]  **Proposal 1.E**: Support. If opponent says that the same setting(s) of (P0, alpha, closed loop index) should be applied to all SRS resources in the same SRS resource set (as same as R15), we can discuss such a ristiction later.  **Proposal 1.F**: Not support. We believe we should focus on remaining issues of M=N=1 first. If time allowes, we can extend it to M, N>1 later. |
| AT&T | Proposal 1.B-1: Support. We are also fine with starting from Ericsson’s proposal. That includes discussing DMRS(s) associated with non-UE dedicated reception on PDSCH and all/subset of CORESETs separately.  Proposal 1.C: support  Proposal 1.F: support |
| Spreadtrum | **Proposal 1.B-1/2:** Regarding the word ‘some’, we suggest to delete it and change ‘can share’ into ‘can be configured to apply’. For Huawei’s comment, we don’t think that periodically transmitted CSI-RS follows the common beam is problematic because PDCCH monitor occasions are literally periodic. On the other hand, for CSI-RS/SRS for BM, we are still not convinced on the use case and benefit of applying the common beam.  **Proposal 1.C:** Support.  **Proposal 1.D:** Support.  **Proposal 1.E:** Support.  **Proposal 1.F:** Based on the agreement from last meeting, we should decide whether to support M/N>1 and if support, identify and agree on use cases. Therefore, making some use cases as FFS and support them in further meeting seems not desired.  [Mod: Use cases have been included, FFS only for the details of sTRP] |
| Lenovo/MotM | Proposal 1.B-1: We are OK with the proposed text. We notice in the main bullet “The following DL RSs can share the same indicated Rel-17 TCI state…” It implies these RS may or may not share the same indicated TCI state. We think this flexibility is important, and which CSI-RS for CSI or for BM, or DMRS associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs shall be left for gNB to decide and to signal to the UE.  We propose to add a bullet at the end of this proposal:  “How to signal to the UE which CSI-RS resources for CSI or for BM, or DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs share the indicated R17 TCI is FFS”.  [Mod: please check latest version]  Proposal 1.B-2: Support.  Proposal 1.C: We still think there is benefit for extending R17 TCI framework to DL RS that does not share the same R17 TCI state with UE-dedicated PDSCH and PDCCH. Whether to use R17 or R15/16 TCI indication scheme shall be left to gNB.  Proposal 1.D: We think beam alignment shall be defined as the event that the spatial relation RS in the UL or (if applicable) joint TCI state and PL-RS are either identical or share the same SSB as QCL-TypeD. Otherwise there is no beam alignment. We propose to change the proposal to:  **Proposal 1.D (from Chairman notes v5)**: On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, “beam alignment” is defined as follows:   * Beam alignment is defined as the event that the PL-RS is identical to the spatial relation RS in the UL or (if applicable) joint TCI state. If not identical, beam alignment is defined as the event that the spatial relation RS in the UL or (if applicable) joint TCI state and PL-RS ~~are~~ share the same QCL~~-ed~~ ~~with respect to~~ TypeD ~~QCL~~ SSB. * Any other case, there is no beam alignment   [Mod: Given the source of debate is the case when they are not identical, we first focus on the identical case. Otherwise we cannot progress]  Proposal 1.E: Support  Proposal 1.F: Support |
| OPPO | **Proposal 1.C:** support.  **Proposal 1.E:** do not support.We do not see the technical reason for updating PC setting for SRS for every TCI state switch.  **Proposal 1.F:** we do not support to support all the combinations of M/N with FFS on the use case.We shall first agree on the use case and then discuss and agree on the corresponding M/N  [Mod: Use cases have been included, FFS only for the details of sTRP] |
| Xiaomi | **Proposal 1.B,** We need to first make it clear what is UE-dedicated reception on CORESET or non-UE dedicated reception on CORESETs. If the first one is USS set and the second one is CSS set, does it mean the unified TCI state will be applied per SS set? We can support the version from MTK.  [Mod: separated DMRS from CSI-RS, with MTK’s version]  **Proposal 1.F,** First it is about some sTRP use cases, we think if which sTRP use case is not decided, it is better not to include it in the main bullet. As for inter-cell beam management, from our understanding, it can be covered by S-DCI or M-DCI mTRP use case. I want to know which special case can’t be covered by mTRP use case.  [Mod: some companies cannot accept if sTRP is not included ☹]  The second is that we support M >1 and or N >1 for mTRP, but we prefer M-DCI multi-TRP first. Since for M-DCI multi-TRP, the MAC CE/DCI are similar to that as M=1 and N=1 in sTRP, it means only small spec effort is needed to support it. But for S-DCI mTRP case, much more spec effort is needed, including MAC CE and DCI. For MAC CE, may be up to 4 TCI states should be supported for each TCI codepoint if separate TCI state is needed. In this case, it is possible that the 3 bits TCI field may be not sufficient.  [Mod: Understood. Changed Xiaomi from support to not-support] |
| CATT | **Proposal 1.B-1**: We are OK with Ericsson’s proposal.  **Proposal 1.B-2**: Support.  **Proposal 1.C**: Not support. We prefer a unified TCI configuration scheme in Rel-17. As M>1, N>1 would be supported in Rel-17, similar signalling framework may be considered.  **Proposal 1.D**: Support.  **Proposal 1.E**: Support.  **Proposal 1.F**: Support. For the last bullet, the example is not quite clear to us. We agree with Samsung’ s proposal. |
| Vivo | **Proposal 1.B-1 and Proposal 1.B-2:**  Do not support the proposal in current form. As we mentioned in Round0, the CSI-RS for BM and SRS for BM are used for beam tracking and refinement through beam sweeping, the gNB and UE can flexibly measure beam pair link for different DL TCI state from the UE-dedicated reception on PDSCH or all or subset of CORESETs, or different UL TCI state from dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources.Similarly, for CSI-RS for CSI acquisition, the UE also can maintain CSI measurement for different TCI states flexibly, not limited to measure CSI based on indicated joint TCI state or separate DL TCI state.  For DMRS(s) associated with non-UE-specific CORESET, the behavior for L1/L2 mobility should be clarified firstly, because they are related to inter-cell beam management.  The revised proposal from E/// seems more reasonable.  **Proposal 1.B-1**: On Rel.17 unified TCI framework:   * The following DL RSs can share the same indicated Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC   + Aperiodic CSI-RS resources for CSI at least when the triggering offset is smaller than within *beamSwitchTiming*;   + Aperiodic CSI-RS resources for BM at least when the triggering offset is smaller than within *beamSwitchTiming*;   FFS: Other CSI-RS time-domain behaviors  [Mod: Added this in brackets, see what other companies think]  **Proposal 1.C:**  This proposal depends on the Proposal 1.B.  **Proposal 1.D: S**upport  **Proposal 1.E:** Support  **Proposal 1.F:**  For M>1 and/or N>1 beam indication, a direct solution is that multiple channel/RS types are flexibly grouped to apply a same TCI state. The group index can be added in multiple channel/RS configuration, or the group configuration including multiple channel/RS is provided by gNB.  **Proposal 1.F**: On Rel-17 unified TCI, in addition to (M,N)=(1,1), the following combinations are supported: (M,N)=(2,1), (1,2), and (2,2) for mTRP and some sTRP use cases   * Note: At least in Rel-17, the support of N=2 does not imply the support of STxMP * FFS: Which sTRP use case(s) and other use case(s), e.g. inter-cell beam management, MP-UE, inter-band CA * FFS: How to support M>1 and/or N>1, e.g., association between a Rel-17 unified TCI state with a group of beams, or multiple channel/RS types are flexibly grouped to apply a same Rel-17 TCI state. |
| LG | **Proposal 1.B.1 and 1.B.2: Support**   * If we remove ‘some’ from the subbullets, we should clarify that this does not apply to all configured CSI-RS/SRS resources and gNB shall indicate which CSI-RS/SRS resources to be applicable or not applicable.   **Proposal 1.C: Support**  **Proposal 1.D:** For the definition of ‘beam alignment’ on PL RS, it is stillunclear how to define beam alignment when spatial relation RS is SRS for UL TCI. We think that PL measurement for the SRS can be straight-forwardly used in that case. We propose the following modification:  **Proposal 1.D (from Chairman notes v5): On path-loss measurement for Rel.17 unified TCI framework, at least for discussion purposes, “beam alignment” is defined as follows:**   * **When spatial relation RS in the UL or (if applicable) joint TCI state is a CSI-RS or an SSB,**    + **Beam alignment is defined as the event that the PL-RS is identical to the spatial relation RS in the UL or (if applicable) joint TCI state. If not identical, beam alignment is defined as the event that the spatial relation RS in the UL or (if applicable) joint TCI state and PL-RS are QCL-ed with respect to TypeD QCL.** * **When spatial relation RS in the UL TCI state is an SRS,**    + **Beam alignment is defined as the event that the PL-RS is identical to the PL RS of the SRS.** * **Any other case, there is no beam alignment**   [Mod: Given the source of debate is the case when they are not identical, we first focus on the identical case. Otherwise we cannot progress]  **Proposal 1.E: Support**  **Proposal 1.F: Support** |
| ZTE | **Proposal 1.B-1/2:** Support. Then Ericsson’s suggestions seem to be a good way-forward solution, and we can NOT live with the condition for AP-CSI-RS, e.g., < threshold.  [Mod: Still in brackets now]  **Proposal 1.C:** Support  **Proposal 1.D:** Support. We are also fine for concluding the case of ‘the PL-RS is identical to the spatial relation RS in the UL or (if applicable) joint TCI state’.  **Proposal 1.E:** Support. @OPPO, please review our following technical reason: Unified TCI state is supposed to be applied for SRS with the same Tx beam as PUSCH, and it is straightforward that such SRS should share the same closed loop value with the currently active closed loop of PUSCH. That is, the closed loop procedure for SRS should be tied with the currently active PUSCH closed loop, and consequently, considering dynamic switching for PUSCH closed loop index, the association is very necessary.    **Proposal 1.F:** Support in principle. Regarding the last bullet, we suggest to add the case of mapping between each of M/N TCI states with TRP   * FFS: How to support M>1 and/or N>1, e.g., association between a Rel-17 unified TCI state with a group of beams, how to mapping between each of M/N TCI states with a respective TRP. |
| Mod V18 | Revised  Proposal 1.D is stable content-wise if we keep the non-identical case FFS.  Proposal 1.B-1, 1-B-2, and 1.E are supported by super-majority  Proposal 1.B-3, 1.C, 1.F need more discussion |
| CMCC | **Proposal 1.F**: Not support. We think it is natural to support mTRP with M, N>1. But the FFS point of “some” sTRP use case is not clear to us. We are also fine to discuss M, N>1 in Rel-18.  [Mod: Updated Table 1] |
| Mod V20 | No revision from V18 |
| Fraunhofer IIS/HHI | Proposal 1.B-1: Support in principle. The FFS can be changed as follows: ‘Other CSI-RS time-domain behaviors and/or restrictions’  Proposal 1.B-2, 1.B-3, 1.D: Support  Proposal 1.F: Have similar view as Apple and CMCC. Support M, N>1 for mTRP use cases, not STRP. |
| Sony | **Proposal 1.B-1, Proposal 1.B-2 and Proposal 1.B-3:** support in principle, since in the main bullet it says, “can share…”, rather than “shall share…”, so we think the flexibility matters. In addition, like many others, we would prefer to remove “some” which seems vague and unnecessary (FFS lists some conditions to apply common TCI states to these RS).  **Proposal 1.F:** Not support.  In our understanding, any of 4 (M, N) combinations in the proposal needs to be conveyed via e.g. one DCI codepoint as joint TCI state where (M, N) = (1, 1) has been supported. We see potential use case of (M, N) = (2, 2) for mTRP, but neither for sTRP nor the combinations of (M, N) = (1, 2) or (M, N) = (2, 1). Perhaps like many other pointed, we should first discuss and decide use case(s) in the first place.  In addition, the more combinations of joint TCI states can be, the less TCI states can be activated by MAC CE (following Rel.16 enhance MAC CE design for TCI state activation for PDSCH, only up to 3 bits for TCI states in DCI).  since “which sTRP use cases” are listed FFS in the 2nd sub-bullet, it would be better to remove “some sTRP use cases” in the main bullet. |
| NTT Docomo2 | **Proposal 1.B-1:** Support. We agree A-CSI-RS is the most essential. We’d like to support A-CSI-RS, irrespective of *beamSwitchTiming*, but we are fine with the current formulation (i.e. we are fine to remove [ ]).  **Proposal 1.B-2, 1.B-3, 1.C:** Support.  **Proposal 1.D:** Fine.  **Proposal 1.E:** Support.  **Proposal 1.F:** Not support. We prefer to discuss M, N >1 later. |
| MediaTek | **Proposal 1.B-1:** We believe the intention of this proposal is mainly for the case when the triggering offset is “larger” than *beamSwitchTiming*, and we prefer to support it irrespective of *beamSwitchTiming.* |
| Mod V26 | Only minor revision for 1.B-1 on FFS. Overall the proposals are stable content-wise (since V18).   * Proposal 1.D seems agreeable if we keep the non-identical case FFS. * Proposal 1.B-1, 1-B-2, and 1.E are supported by super-majority * Proposal 1.B-3, 1.C, 1.F need more discussion   The texts in brackets related to beamSwitchTiming don’t seem agreeable to at least 3 companies (ZTE, NTT Docomo, MediaTek) |

### Issue 2 (inter-cell beam management)

Table 3 Summary: issue 2

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1 | Agreement  On Rel.17 beam indication enhancements for ~~L1/L2-centric~~ inter-cell beam management ~~mobility~~, support the following:   * Rel-17 MAC-CE-based and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation)   + [2.1.1] FFS (to be decided in RAN1#106-e): Whether this also applies to PDSCH/PUSCH associated with UE-dedicated CORESETs only or additional target channels (e.g. UE-dedicated PDCCH/PUCCH)   + [2.1.2] FFS: Whether the above is supported only for joint TCI, or both joint TCI and separate DL/UL TCI (including that, if separate DL/UL TCI is supported, the DL TCI and UL TCI associated with a same cell)   + [2.1.3] FFS: Whether to support activation of TCI states for more than one cells simultaneously   + [2.1.4] FFS: Whether down-selection between MAC-CE only based and MAC-CE+DCI-based beam indication scheme is necessary * The DL QCL and UL spatial relation rules already agreed for intra-cell scenario   + Already agreed up to RAN1#106-e day2 * [2.1.5] FFS: The use of SSB associated with a physical cell ID different from that of the serving cell as an indirect QCL reference for UE-dedicated PDSCH   + FFS (to be decided in RAN1#106-e): Whether this also applies to UE-dedicated PDCCH   + Note: When RS X is an indirect QCL reference of a target channel, there exists at least one other source signal on the QCL chain between RS X and the target channel   + FFS (to be decided in RAN1#106-e): Whether SSB associated with a physical cell ID different from that of the serving cell can also be used as a direct QCL reference (source RS) for UE-dedicated PDCCH/PDSCH | 2.1.1: TCI applied to:   * Data and control (delete FFS): vivo, Samsung, Ericsson, Apple, NTT Docomo, MTK, Sony, Xiaomi, CATT (PDCCH/PUCCH optional), Intel, ZTE * Data only:   2.1.2:   * Joint: Samsung, Ericsson, NTT Docomo, Intel, Xiaomi, ZTE, CATT * Separate: MTK (DL NSC, UL SC), Ericsson, NTT Docomo, Samsung (DL and UL associated with the same cell), Intel, Xiaomi,,CATT   2.1.3:   * One cell: CATT, OPPO, MTK, Apple, Xiaomi, ZTE * More than one cell: Samsung, NTT Docomo   2.1.4:   * MAC-CE only: Huawei/HiSi * MAC CE+DCI only: * No Downselection (delete FFS): Sony, Samsung, CATT, Fujitsu, Ericsson, NTT Docomo, ZTE, MTK, Qualcomm, Intel, Xiaomi   2.1.5:   * SSB Indirect QCL only: Huawei, Sony, OPPO, CMCC, Ericsson, Apple, Intel, LG, CATT * SSB Direct+Indirect QCL: Samsung, NTT Docomo, MTK, ZTE |
| 2.8 | Synchronization and timing advance assumptions between cells  Note: This issue was identified in RAN#92 | Single TA value across cells: OPPO, MTK    Multiple TA values across cells: vivo, Futurewei, Qualcomm, Intel, [Ericsson], Apple, NTT Docomo, Sony, ZTE  Reporting timing offset in beam report: vivo  PRACH for TA measurement: Apple, NTT Docomo, ZTE |
| 2.9 | What “a UE can transmit to or receive from only a single cell” (DPS) entails  Note: This issue was identified in RAN#92 | UE-specific channels: [Huawei/HiSi], Samsung, Futurewei, Ericsson, Intel  All data and control channels: Apple, MTK, ZTE |
|  |  |  |

**Proposal 2.A.1**: On Rel.17 beam indication enhancements for inter-cell management, the supported Rel-17 MAC-CE-based (when one TCI state is activated) and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation) applies to:

* PDCCH/PUCCH/PDSCH/PUSCH configured to the same cell

**Proposal 2.A.2**: On Rel.17 beam indication enhancements for inter-cell management, for the supported Rel-17 MAC-CE-based (with only one activated TCI state) and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation):

* Both joint TCI and separate DL/UL TCI
* FFS: For separate DL/UL TCI, whether the indicated DL TCI and UL TCI are associated with SSBs of a same physical cell ID

**Proposal 2.A.3**: On Rel.17 beam indication enhancements for inter-cell management, for the supported Rel-17 MAC-CE-based (with only one activated TCI state) and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation):

* Support a UE feature on how many cells (including the serving cell) can be associated with the activated TCI states, where the list of candidate values includes 1

**Proposal 2.A.4**: On Rel.17 beam indication enhancements for inter-cell management, for the supported Rel-17 MAC-CE-based (with only one activated TCI state) and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation):

* Both MAC-CE based and MAC-CE+DCI-based beam indication schemes are supported

**Proposal 2.A.5**: On Rel.17 beam indication enhancements for inter-cell management, SSB associated with a physical cell ID different from that of the serving cell is used as an indirect QCL reference at least for UE-dedicated PDSCH and UE-dedicated PDCCH

* Note: When RS X is an indirect QCL reference of a target channel, there exists at least one other source signal on the QCL chain between RS X and the target channel. Here, Rel-15/16 QCL rule is reused by replacing SSB with SSB associated with a physical cell ID different from that of the serving cell

Table 4 Additional inputs: issue 2

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Share your inputs on the above FL proposals** |
| Ericsson | Proposal 2.A.1: Support  Proposal 2.A.2: Support  Proposal 2.A.3: We think the limitation on activation of TCI states is relevant. But this should be a UE feature. Hence we propose:  **Proposal 2.A.3**: On Rel.17 beam indication enhancements for inter-cell management, for the supported Rel-17 MAC-CE-based (with only one activated TCI state) and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation):   * Support a UE feature on how many cells can be associated with the activated TCI states, where the list of candidate values includes 1.   [Mod: see latest version]  Proposal 2.A.4: Support   * Proposal 2.A.5: Support |
| Samsung | **Proposal 2.A.1**: Support no need for square brackets.  **Proposal 2.A.2**: Support  **Proposal 2.A.3**: We would like to clarify the intention. Is the the intention to activate TCI states for one additional cell (in addition to the serving cell), or to activate TCI states for one cell including the serving cell. The latter might be two limiting for fast beam indication as it requires MAC CE activation. We suggest the following update:  On Rel.17 beam indication enhancements for inter-cell management, for the supported Rel-17 MAC-CE-based (with only one activated TCI state) and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation):   * Activation of TCI states for one cell, in addition to the serving cell, is supported * FFS: Whether >1 cells can be supported   [Mod: correct, added]  Fine also to have a UE feature, as suggested by Ericsson for the number of additional cells with [actvated] TCI states.  **Proposal 2.A.4:** Support  **Proposal 2.A.5:** We would like to additionally support SSB as a direct QCL source.  There should be a proposal similar to proposal 2.A.5 for UL channels:  On Rel.17 beam indication enhancements for inter-cell management, SSB associated with a physical cell ID different from that of the serving cell is used as an indirect or direct QCL reference for UE-dedicated PUSCH and UE-dedicated PUCCH   * Note: When RS X is an indirect QCL reference of a target channel, there exists at least one other source signal on the QCL chain between RS X and the target channel   Direct SSB is already support for UL channels in case of intra-cell beam management.  [Mod: More companies are against SSB for direct QCL ☹ The focus of this proposal is DL] |
| Qualcomm | For Proposal 2.A.1, suggest to remove bracket and “some of”. Because unified TCI indication can be applied to all channels/RSs configured for the serving cell. We do not prefer to use other beam indication additionally.   * ~~[~~This applies to ~~some of the~~ PDCCH/PUCCH/PDSCH/PUSCH configured to the same cell~~]~~   [Mod: Done]  For Proposal 2.A.2, support. For the FFS, prefer no restriction to same cell  For Proposal 2.A.3, support. The FFS can be up to UE capability.  For Proposal 2.A.4, support  For Proposal 2.A.5, support |
| Intel | Firstly, based on online discussion, we want to clarify the understanding of inter-cell beam management. Based on RAN2 LS, our understanding is that Scenario 1 is only supported. In this case, the configuration of the PxSCH/PxCCH transmission are received from the serving cell (RRC), however, the channels themselves are received from a non-serving cell (TRP) i.e., TRP with different PCID. Therefore, for the purposes of inter-cell beam management, non-serving cell refers to a TRP with different PCID while all configurations are received from the serving cell. Additionally, UE never leaves “coverage” of serving cell i.e., common control signaling is received from the serving cell. Our comments are based on this understanding.  [Mod: The channels can be received from cells other than SC. But from UE perspective this is always configured from the SC since it was agreed that there is no change in serving cell. Thus the wording. ]  **Proposal 2.A.1:** The main bullet wording can be improved. Furthermore, for the sub-bullet, is the intention that this refers to the PxSCH/PxCCH received from the “non-serving cell”? This should be clearly mentioned. We are not sure what “configured to the same cell” means.  On Rel.17 beam indication enhancements for inter-cell management, ~~for~~ the supported Rel-17 MAC-CE-based (~~with~~ when only one ~~activated~~ TCI state is activated) and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation) applies to:   * ~~[This applies to some of the~~ PDCCH/PUCCH/PDSCH/PUSCH configured by the serving cell and associated with a TRP with different PCID (non-serving cell) ~~]~~   **Proposal 2.A.2:** We are still not clear about the purpose of the FFS point.  [Mod: Some companies would like to discuss if we should allow the case where UL and DL are assocaited with different cells for separate TCI. ]  **Proposal 2.A.3:** Is it correct understanding that with the first main bullet, if only TCI states from one cell can be activated, DCI based switching is precluded, since we need to use MAC-CE based activation every time a non-serving cell TCI is to be used/indicated? This restriction seems limiting specially since the aim of this work is so-called fast beam switching. It may be an additional UE capability i.e., UEs which do not support this can only use MAC-CE activation.  [Mod: No – I am not sure how this can be inferred from the wording. MAC CE only is used when only one TCI state is activated (clearly mentioned in the main sentence.]  **Proposal 2.A.4/5:** OK |
| Apple | Proposal 2.A.1: we think the controversial part is the target channel, we suggest we list potential alternatives. We share the same view with QC that all PDCCH/PDSCH/PUCCH/PUSCH should be target channel. We understand some companies want “some of”, but we would like to understand the details on the following issues:   * Q1: What is the “some of” channels? * Q2: How to provide beam indication for the other channels? * Q3: How to define the default PDSCH beam? * Q4: How to support the UE that can only support 1 active TCI states?   [Mod: Q2 is related to proposal 1.B-x. ‘Some’ removed]  Proposal 2.A.2: If separate TCI is supported, we think the sentence “For separate DL/UL TCI, whether the DL TCI and UL TCI are associated with a same cell” should be supported.  [Mod: A number of companies cannot agree to this at this point. I suggest we progress with what we can.]  Proposal 2.A.5: We think it should be applicable not only for UE-dedicated channel but also for common channel.  [Mod: This is related to 2.A.1. Added ‘at least’ to accommodate your preference for now] |
| MediaTek | Proposal 2.A.1: Support and suggest to remove the brackets and “some of the” in the sentence.  [Mod: Removed]  Proposal 2.A.2: Support  Proposal 2.A.3: We are fine with Ericsson’s suggestion with one minor change.  **Proposal 2.A.3**: On Rel.17 beam indication enhancements for inter-cell management, for the supported Rel-17 MAC-CE-based (with only one activated TCI state) and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation):   * Support a UE feature on how many cells (including the serving cell) can be associated with the activated TCI states, where the list of candidate values includes 1.   Proposal 2.A.4: Support  Proposal 2.A.5: Share the same view with Apple. Non-UE-dedicated should be included as well. |
| NTT Docomo | For Proposal 2.A.1, Support. Suggest to remove bracket and “some of the”. Since R15/16 beam management is not allowed for L1/L2 inter cell mobility, unified TCI is only the way to indicate beams.  [Mod: Done]  Proposal 2.A.2/3/4/5: Support. |
| AT&T | Proposal 2.A.1/2/4/5: support  Proposal 2.A.3: Is the activation of TCI states for one cell limited only to the serving cell?  [Mod: clarified. One means SC only but multiple is supported] |
| Spreadtrum | **Proposal 2.A.1**: Suggest to change as follows,   * [This applies to ~~some of~~ the PDCCH/PUCCH/PDSCH/PUSCH configured to the same cell that can share the same indicated Rel-17 DL, UL or (if applicable) joint TCI state]   [Mod: This additional detail can be discussed later since it is related to proposals 1.B-x]  **Proposal 2.A.2:** Support  **Proposal 2.A.3**: Support the proposal. Regarding the FFS, based on the conclusion made in RAN#92e that ‘a UE can transmit to or receive from only a single cell’, UE is not required to maintain active TCI states for multiple cells at the same time duration. And one more change for clarification,   * Activation of TCI states for one (serving/non-serving) cell is supported   **[Mod: please check latest version per Ericsson’s comment]**  **Proposal 2.A.4:** Support  **Proposal 2.A.5:** Support |
| Lenovo/MotM | Proposal 2.A.1: The bracket shall be removed, otherwise there is no statement in this proposal.rt  Proposal 2.A.2: We support the first bullet, but need a clarification for the second bullet (FFS). Does “the DL TCI and UL TCI are associated with a same cell” mean “the DL TCI and UL TCI are associated with a same PCID”?  [Mod: correct, added]  Proposal 2.A.3: Support.  Proposal 2.A.4: Support.  Proposal 2.A.5: Support. |
| OPPO | Proposal 2.A.1: Suggest to remove the bracket and also remove the “some”. Furthermore, as stated in the WID, no cell changing is assumed. So by default, all the PDSCH/PDCCH/PUSCH/PUCCH are in the serving cell, the UE does not see any non-serving cell for reception or transmission of those channels.  2.A.2: Suggest to change the FFS wording as follows:   * FFS: For separate DL/UL TCI, whether the DL TCI and UL TCI are associated with SSBs of a same ~~cell~~ physical cell ID~~.~~   The reason for the suggested change is we assume no serving cell change for this work. In this “inter-cell beam management”, we do not have TCI state that is associated with any cell.  [Mod: Done]  2.A.3: suggest to change one sub-bullet as follows   * Activation of TCI states associated with SSBs of same physical cell ID ~~for one cell~~ is supported   [Mod: please check latest version]  2.A.4: support  2.A.5: prefer to add a note: rel15/re1l16 QCL rule is reused by replacing SSB with SSB associated with a physical cell ID different from that of the serving cell. This note is used to avoid any confusion on the “indirect QCL”  [Mod: Done] |
| Xiaomi | **Proposal 2.A.1**, support with removing bracket and “some of the”. And we also fine with the version from Intel since we need to focus on non-serving cell only.  [Mod: Done]  **Proposal 2.A.2**, we think it has some relation with M>1 and/or N>1. For M-DCI inter-cell mTRP case, we think both joint TCI and separate DL/UL TCI can be supported. While for S-DCI inter -cell mTRP case, we think joint TCI can be supported first. Since for MAC CE, may be up to 4 TCI states should be supported for each TCI codepoint if separate TCI state is needed. In this case, it is possible that the 3 bits TCI field may be not sufficient.  [Mod: I don’t think this depends on M/N. Even if M/N>1 is not supported (very likely outcome – check table 1), this proposal clearly holds – no need to wait for M/N outcome]  **Proposal 2.A.3,** support and also fine with the version from Samsung by adding “in addition to the serving cell”.  **Proposal 2.A.4,** support  **Proposal 2.A.5,** support |
| CATT | Proposal 2.A.1: We agree with MTK’s proposal, where some common DL channels may be received from the serving-cell.  Proposal 2.A.2: Support. For the FFS point, we prefer to limit the UL TCI and DL TCI associated with the same cell. This is also related to the FFS point of Proposal 2.A.3, i.e. FFS: Whether >1 cells can be supported  Proposal 2.A.3: Support  Proposal 2.A.4: Support  Proposal 2.A.5: Support |
| vivo | Proposal 2.A.1: We share similar view as Intel. We would also like to clarify the understanding on “some of the PDCCH/PUCCH/PDSCH/PUSCH” before jumping into agreement. One question in addition to Apple’s list of questions:  Question: What are companies understanding with RAN2’s agreement: “UE receives and transmits using UE-dedicated channel on TRP with different PCI” and “UE should use common channels BCCH PCH etc. from the serving cell (as in legacy)”?   * RAN2 confirm the simplified procedures on the inter-cell multi-TRP-like model as a baseline RAN2 understanding:   Scenario 1: Inter-cell multi-TRP-like model  1. UE receives from serving cell, configuration of SSBs of the TRP with different PCI for beam measurement, and configurations needed to use radio resources for data transmission/reception incl resources for different PCI.  2. UE performs beam measurement for the TRP with different PCI and report it to serving cell.  3. Based on the above reports, TCI state(s) associated to the TRP with different PCI is activated from the serving cell (by L1/L2 signaling).  4. UE receives and transmits using UE-dedicated channel on TRP with different PCI.  5. UE should be in coverage of a serving cell always, also for multi-TRP case, e.g. UE should use common channels BCCH PCH etc. from the serving cell (as in legacy).  [Mod: The current wording says all the channels are configured form/by the SC (which is the case form UE perspective). After ‘some’ is removed, I believe it is now clear.]  Proposal 2.A.3: Samsung’s update is fine. |
| LG | Proposal 2.A.1: For the first bullet, it seems to add an FFS for the details when the beam indication applies to ‘some’ of the UL/DL data and control channels as follows.  Proposal 2.A.1: On Rel.17 beam indication enhancements for inter-cell management, for the supported Rel-17 MAC-CE-based (with only one activated TCI state) and/or DCI-based beam indication (at least using DCI formats 1\_1/1\_2 with and without DL assignment including the associated MAC-CE-based TCI state activation):   * This applies to some of the PDCCH/PUCCH/PDSCH/PUSCH configured to the same cell   + FFS: How to select/configure the target channel(s)   [Mod: please check my comment to Apple]  Proposal 2.A.5: Support |
| ZTE | Proposal 2.A.1, we share the same views with QC and Apple that the unified TCI indication can be applied to all channels/RSs configured for the serving cell. ‘some of XXX ’ is a little bit confusing.   * ~~[~~This applies to ~~some of the~~ PDCCH/PUCCH/PDSCH/PUSCH configured to the same cell~~]~~   Proposal 2.A.2, support in principle. We think that for separate DL/UL TCI, whether the DL TCI and UL TCI are associated with a same cell, and the ‘FFS’ should be removed.  Proposal 2.A.3, we are fine with Samsung’s update.  Proposal 2.A.4, support. We suggest to treat them equally.  Proposal 2.A.5: we share the same views with Samsung that we need to support direct QCL chain for SSB also. |
| Mod V18 | Revised. Proposals 2.A.2 to 2.A.5 seems stable content-wise. 2.A-1 is getting there. |
| CMCC | Proposal 2.A.1: Support.  Proposal 2.A.2: Suggest to change the FFS wording as follows:   * FFS: For separate DL/UL TCI, whether the indicated DL TCI and UL TCI are associated with SSBs of a same ~~cell~~ physical cell ID~~.~~   we think the activated DL TCI and UL TCI by MAC-CE can be associated with SSBs of different PCI (depends on 2.A.3), the intention should be the indicated TCI.  [Mod: Done]  Proposal 2.A.3: Support.  Proposal 2.A.4: Support.  Proposal 2.A.5: Support. |
| Mod V20 | Minor revision from V18 on 2.A.2 |
| Sony | **Proposal 2.A.1:** support with removing the bracket and the vague word “some”.  One clarification question is whether “the same cell” in the sub-bullet refers to a non-serving cell? If yes, from our reading of RAN2/RAN4 LS, they are somehow confused by the term “non-serving cell” though RAN1 may feel comfortable. So we hope all RAN WGs could get aligned on what we are talking about, therefore avoid misunderstanding.  **Proposal 2.A.2:** support and slight wording change suggested as   * Both joint TCI and separate DL/UL TCI are supported   **Proposal 2.A.3:** fine with the rewording from Samsung  **Proposal 2.A.4:** support the FL proposal  **Proposal 2.A.5:** support the FL proposal |
| vivo2 | We do not support Proposal 2.A.1, since it is against the RAN2 agreement.  For other proposals about issue2, we support.   |  | | --- | |  RAN2 confirm the simplified procedures on the inter-cell multi-TRP-like model as a base-line RAN2 understanding:  Scenario 1: Inter-cell multi-TRP-like model  1. UE receives from serving cell, configuration of SSBs of the TRP with different PCI for beam meas urement, and configurations needed to use radio resources for data transmis-sion/reception incl resources for different PCI.  2. UE performs beam measurement for the TRP with different PCI and report it to serving cell.  3. Based on the above reports, TCI state(s) associated to the TRP with different PCI is ac-tivated from the serving cell (by L1/L2 signaling).  4. UE receives and transmits using UE-dedicated channel on TRP with different PCI.  5. UE should be in coverage of a serving cell always, also for multi-TRP case, e.g. UE should use common channels BCCH PCH etc. from the serving cell (as in legacy). | |
| NTT Docomo2 | **Proposal 2.A.1, 2.A.2:** Support.  **Proposal 2.A.3**: Suggest to update (including the serving cell) to (in addition to the serving cell), as commented by Samsung. If the UE capability can report “1” (including the serving cell), it means L1/L2 inter cell mobility is not supported. We don’t need to create such a meaningless UE capability.  [Mod: Please check MTK’s comment which I think valid]  One question: Does the UE capability intend to report the number of “RRC-configurable PCIs” or “active PCIs, which is activated by MAC CE (RRC can configure larger number than active PCIs)”? This will be discussed later?  [Mod: We can discuss later]  **Proposal 2.A.4, 2.A.5**: Support. |
| MediaTek | **Proposal 2.A.3**: Re comment from Docomo, sorry, current wording may lead to confusion that TCI must be activated at least for the serving cell. We can go back to the original wording suggested by Ericsson. However, we don't prefer to use “in addition to the serving cell” since it is possible to activate TCI for only one non-serving cell w/o serving-cell. If UE reports support of one cell, NW can either activate TCI for a non-serving cell or a serving cell. |
| Mod V26 | No revision. All proposals are stable (content-wise since V18).   * 2.A.1 seems agreeable to (super) majority – so far only vivo and perhaps Intel voice concern * 2.A.2-5 seem agreeable |

### Issue 3 (beam indication signaling medium)

Table 5 Summary: issue 3

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 3.1 | Further details on beam application time (BAT):   1. Whether different values of X/Y are needed for some scenarios – and if so, which scenarios? | **BAT for CA:**   * **Smallest SCS:** Huawei/HiSi, vivo, MTK * **Determined/indicated dynamically:** ZTE, NTT Docomo * **Determined by CC with largest delay:** Samsung, NTT Docomo (if BAT is SCS dependent value, and if CA in different SCS) * **Additional offset for cross carrier beam indication:** vivo, Nokia/NSB   **Panel-dependent beam latency:** vivo (panel activation delay), IDC, CATT (2 BATs for inter-panel and intra-panel), LGE, Samsung, FGI/APT  **Single beam application time**: OPPO, MTK |
|  |  |  |

**Agreement**

On Rel-17 DCI-based beam indication, regarding application time of the beam indication, the first slot that is at least X ms or Y symbols after the last symbol of the acknowledgment of the joint or separate DL/UL beam indication.

* Note: The gap between the last symbol of the beam indication DCI and that first slot shall satisfy the UE capability
* FFS: Application time and whether additional offset is needed for the application time in case of cross carrier beam indication and common TCI state ID update across a set of configured CCs if CCs have different SCSs
* FFS: Whether inter-cell beam switching needs higher X/Y values than intra-cell
* FFS: Whether application time can be indicated/determined dynamically for different scenarios, e.g. cross CC, inter-cell, inter-panel without reverting previous RAN1 agreements

Table 6 Additional inputs: issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your views on the following issues:**   * + - 1. **Whether BAT should be defined in terms of X ms (hence not SCS dependent) or Y symbols (hence SCS dependent)**       2. **How to determine BAT in case of CA (including scenarios with mixed numerology)** |
| Ericsson | 1. BAT should be defined in terms of symbols  2. Is this the configured threshold or the capability? For the configured threshold, it would seem unimportant. For the capability, utilize the higher BAT among the involved CC: multiply the per-CC BAT with the symbols time, take the max. |
| Samsung | 1. The BAT can be defined in symbols The BAT can depend on the SCS spacing and can depend on a UE capability. 2. In case of CA, with a common beam indicated across multiple CCs. There is one one beam application time across all CCs, and this is determined by the CC with the longest BAT. |
| Qualcomm | For Q1: symbol, since the application time can be much shorter than 3 ms and SCS dependent  For Q2, use smallest SCS among CCs to which new TCI is applied |
| Intel | Q1: better to define in symbols  Q2: Use the smallest SCS among the CCs |
| Apple | Q1: X ms. Y symbols based on a SCS = X ms.  Q2: X ms is applied to all CCs. |
| MediaTek | Q1: Symbol  Q2: For common beam operation across a set of CCs, share the view with SS, there should be only one beam application time across the set of CCs, and the beam application time should be determined based on the CC with the smallest SCS among these CCs.  Note that even BAT is defined in terms of X ms, the application slots are still not aligned if CCs have different SCSs since the slot durations are not different. |
| NTT Docomo | 1. Better to define in symbols  2. For CA in different SCS, to enable CA operation, all CCs should maintain the same QCL type D, and hence, BAT on multiple CCs should be aligned across CCs. Hence, we support “Determined by CC with largest delay” for UE capability. Actual BAT is determined by UE capability + gNB configuration. As long as gNB can configure the threshold per BWP (or per CC), gNB can align actual BAT across CCs if gNB wants to apply CA. |
| Spreadtrum | Q1: Symbol  Q2: We prefer a single absolute application time for all of the TCI states and all of the applied CCs. |
| Lenovo/MotM | Q1: Symbol  Q2: The smallest SCS among the CCs shall be used. |
| OPPO | Q1: X is in term of ms to avoid involving the SCS. Furthermore, X ms shall depend on the UE capability and the UE processing capability is not related with the SCS. The symbol length is not fixed value but the UE processing capability is a fixed absolute time. If we define it as symbols, then we will have to define the number of symbols for each SCS and eventually, the results is equivalent to defining X ms.  Q2: the same X ms is applied to all the CCs. |
| Xiaomi | Q1: prefer in symbols  Q2: in case of CA with different SCS, it can be determined by the CC with the longest BAT.  In addition, we want to confirm is there a case that joint TCI with different SCS between DL BWP and UL BWP. If yes, we also need to specify how to determine the BAT. |
| CATT | For Q1: we prefer to define in X ms.  For Q2: if Xms is used for BAT, there is no difference across different CCs. |
| LG | Q1: It is more suitable to define BAT in terms of symbol by taking CA/panel-dependent cases into account |
| ZTE | For Q1: We prefer to define in X ms.  For Q2: If so, there is no different across different CCs. |
| Mod V18 | No proposal added, will do so in round 2 based on all inputs |
| Mod V20 | For Q1, another issue is whether X or Y should be SCS-dependent. If both alternatives are, there seems to be little difference whether we choose X or Y. |
| Sony | Q1: in symbols.  Q2: in case of CA, the BAT could be determined by the smallest SCS (longest duration) among the CCs where the common TCI state(s) apply. One point to clarify is that when we talked about SCS, we by default imply the SCS of UL BWP in which HARQ of beam indication is transmitted, is this correct understanding? If not, we guess the smallest SCS is picked up including DL BWP where beam indication DCI is conveyed.  And the BAT should be subjected to UE related capability. |
| Mod V26 | On Q1, ‘in symbols’ seems to be the majority view  On Q2, most companies prefer one value for all the CCs  I will draft a proposal based on the above inputs |

### Issue 4 (MP-UE)

Table 7 Summary: issue 4

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| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 4.2 | Whether to support CB-based SRS resources with different numbers of ports | **Yes**: Huawei/HiSi, CATT, OPPO, Qualcomm, [Fraunhofer IIS/HHI], Apple (only the SRS set aligned with UE selected panel can be indicated), LGE, NTT Docomo, MTK, IDC  **No**: [vivo], Ericsson |
| 4.3 | Whether to support NCB-based SRS resource sets with different numbers of resources | **Yes**: ZTE, LGE, Apple (only the SRS set aligned with UE selected panel can be indicated), IDC, CATT  **No**: [vivo], Ericsson |
|  |  |  |

**Proposal 4.A**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection, support codebook-based SRS resources with different maximum number of UL MIMO layers per panel entity

* FFS (to be concluded in RAN1#106bis-e, potentially pending the outcome of panel entity indication): whether the indicated SRS set is aligned with the UE selected panel

Table 8 Additional inputs: issue 4

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 7**  **2) Share your input on the above FL proposals** |
| Ericsson | Do not support. The use case is unclear – we have to settle what a “panel entity” is first.  [Mod: please check this conclusion:  On Rel.17 enhancement for facilitating fast uplink panel selection, for discussion purpose, a panel entity corresponds to one or more RS resources:   * For CSI/beam reporting, the RS resource is an RS associated with measurement and/or reporting * For beam indication, the RS resource is a source RS for UL TX spatial filter information * Note: For one RS resource, the corresponding panel entity may vary and is controlled by the UE, and whether/how to maintain a common understanding between gNB and UE can be further discussed/decided * Note: The above does not preclude possibility that an RS resource can be mapped to multiple panels * Note: The one or more RS resources may correspond to one or more RS resource set(s) depending on further discussion/decision * Note: Specification should not be designed in such a way that the UE is required to disclose its antenna implementation   Also this one:  In Rel-17 enhancement for facilitating fast uplink panel selection, the following use cases are assumed:   * MPE mitigation * UE power saving * UL interference management * Support different configurations across panels * UL mTRP   We cannot settle the panel entity ID issue for now. Perhaps this is the only enhancement we could do in Rel-17. ] |
| Samsung | The proposal is unclear since we do not know the correspondence between a panel entity and resources or resource sets. Once this is clarified, we can discuss this.  [Mod: please see my comment to Ericsson.] |
| Qualcomm | Support FL’s proposal. We are open to panel entity definition, e.g. implicitly based on SRS resource set |
| Intel | Do not support. Use case is unclear. |
| Apple | Share the same view with Samsung. We can support it only if the indicated SRS set is aligned with the UE selected panel.  [Mod: added FFS] |
| MediaTek | We think the association between the SRS resource sets and UE panel can be up to UE decision, The problem is if multiple SRS resource sets with different max number of UL MIMO layers are configured, how NW know which one should be triggered if UE doesn’t report any information about UE selected panel? |
| NTT Docomo | Support. And we are fine to further discuss correspondence between panels and resources. Share similar view with MediaTek that we need to consider the problem is if multiple SRS resource sets with different max number of UL MIMO layers are configured, how NW know which one should be triggered if UE doesn’t report any information about UE selected panel? |
| Spreadtrum | Since NW-initiated panel selection has not been agreed, UE can change the active panel and also change the association between the SRS resource sets and the active panel whenever it wants. We are not sure there’s any valid enhancement. |
| Lenovo/MotM | Same view as Samsung. |
| OPPO | The proposal is not clear. If the proposal intends to support SRS resources with different number of ports, that is already supported in rel16. |
| CATT | Fine with FL’s proposal. |
| LG | Support FL’s proposal.  We believe that we had sufficient discussion in the last meeting on the use case and the motivation of the proposal. Especially from UE implementation perspective, it is difficult to apply homogeneous panels (i.e. with same number of antenna elements and beams) due to different location/size available for each panel and different spatial coverage to be achieved by each panel (e.g. top panel covers 180 degree while left panel and right panel cover 90 degree, respectively). Therefore, current restriction of CB/NCB (i.e. same number of ports/layers/beams across SRS resources) should be relaxed to allow various MPUE implementation for various devices.  We also prefer to support this feature for FR1 as well as FR2 for vehicle MPUE implementation, which is being interested by automotive industry (please check 5GAA’s input to 3GPP in RWS-210360). Vehicle UE considers one top panel covering wide area over the vehicle while other panels cover narrow areas, respectively (e.g. front & rear bumpers). So, this feature is very useful for vehicle UE in FR1 as well.  Re panel entity mapping (e.g. resource/resource set/new ID) & management(e.g. UE report): We can discuss these after agreeing on this proposal. Otherwise, we are going round in circles. Note that we have the following agreement.  **Agreement**  On Rel.17 enhancements for MPUE, for codebook based UL transmission, decide by August RAN1 meeting whether to support CB-based SRS resources with different numbers of 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 * FFS: non-codebook based UL transmission for MPUE   FFS whether existing BWP switch based mechanism (discussed previously in Rel-16 power saving WI) can serve such purpose |
| ZTE | We can support FL’s proposal, and we are open to clarify the definition of ‘panel entity’. |
| Mod V18 | Revised.   * For companies who argue that the use cases are not clear, please check previous agreements/conclusions and LG’s response, and see if they address your concerns * Sadly (please check table 7 of round 0 summary) there is no hope to settle the panel entity indication issue for now. I suggest the group not stopping the progress for this using panel entity indication as a condition |
| CMCC | We think the use case is clear. But the discussion of whether a SRS set can corresponds to a panel entity is important to the Proposal. They should be discussed together. |
| Mod V20 | No revision from V18 |
| Fraunhofer IIS/HHI | Support the proposal |
| Sony | Not support at current stage.  We tend to agree with the fact that different panel entity may support different number of max UL layers. But now as Samsung pointed, the correspondence between UE panel entity and CB SRS resource/resource set is not fully determined yet, we hope to come back to this issue when things get clearer.  [Mod: The situation hasn’t changed for several meetings – it seems there may not be any consensus on the panel entity indication in Rel-17. But the proposal doesn’t necessarily depend on whether a new panel ID is supported or not. Please check LG’s argument.] |
| Mod V26 | No revision. Proposal is stable content-wise |
| Samsung2 | Given the explanation from LG and the update (inV18) by the moderator, we can be accept this proposal. |

### Issue 5 (MPE mitigation)

Table 9 Summary: issue 5

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| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 5.2 | If Opt1A/D in 5.1 is supported:   * Alt1. Beam-level reporting * Alt2. Panel-level reporting | **Alt1**: Qualcomm, Convida, Apple, Ericsson, IDC (if Opt 1A+2A)  **Alt2**: Huawei/HiSi, vivo (panel ID in , Spreadturm PHR MAC CE), MotM/Lenovo, Sony, Xiaomi, LG |
|  |  |  |

The following observation can be made:

* 5.1: In round 0 (and since the last meeting), the proponents of 1A and 2A failed to converge. In this round we will try to start from option 1D. The proposal below is made based on the inputs from companies’ contributions and discussion. Note that this is the last attempt (i.e. we will not return to 1A and/or 2A).

**Proposal 5.A**: On Rel.17 enhancements to facilitate MPE mitigation, support the following enhancement on the Rel-16 event-triggered P-MPR-based reporting (included in the PHR report when a threshold is reached, reported via MAC-CE):

* N≥1 P-MPR values can be reported
* FFS: Whether N represents the number of selected beams or the number of panels
* FFS: Whether beam-specific and/or panel-specific PHR is also reported
* FFS: Additional reporting quantities, e.g. SSBRI/CRI, MPR+DL RSRP, UL RSRP, or modified virtual PHR

Table 10 Additional inputs: issue 5

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 9**  **2) Share your inputs on the above FL proposals** |
| Ericsson | Do not support. The proposal (only) does not solve the problem. |
| Samsung | Same view as Ericsson, Opt1D isn’t sufficient.  For progress, we can be open to the following:   * Rel.16 P-MPR reporting is used to trigger beam reporting   + FFS: additional signaling (e.g. CSI trigger) from the NW is needed * Reporting for MPE mitigation via UCI   + Details can be according to Proposal 5.A in round 0, but we can be open to other reasonable proposals   [Mod: This is in the vein of the previous FL proposal (UCI based added on Rel-16 triggering) which couldn’t be agreed even among 1A/2A supporters. Clearly not acceptable to those who insist on using Rel-16 MAC CE report.] |
| Qualcomm | We are fine for Propoal 5.A as start point. P-MPR itself may not tell the link quality. We are fine to report P-MPR+DL RSRP, UL RSRP, or modified virtual PHR per beam. Any above metric should work. |
| Intel | Without SSBRI/CRI, the proposal does not solve the MPE issue. |
| Apple | We think we need SSBRI/CRI, P-MPR, L1-RSRP and closed-loop power control states so that gNB can calculate the actual UL L1-RSRP. P-MPR only is not enough. |
| NTT Docomo | We are fine to start with proposal 5.A. And we are fine to further discuss whether other metrics in addition to P-MPR is needed. |
| Spreadtrum | Support the proposal. SSBRI/CRI is not needed if panel information can be associated with each reported beam. |
| Leovo/MotM | Support. Once agreed, we need to discuss the FFS further. |
| OPPO | Support it in principle |
| MediaTek | We see Proposal 5.A may work only if N P-MPR values correspond to the N beams selected by UE from a pool candidate beams. |
| Xiaomi | Support. Prefer panel specific. |
| CATT | Do not support. Without CRI/SSBRIs of the candidate uplink beam, gNB won’t know which uplink beam does each reporting P-MPR correspond to, thus can’t choose a beam to indicate for the latter uplink transmission. |
| vivo | Support N represents the number of panels.  Complicated environment sensing and MPE event detection with sufficient accuracy at beam level would not be implemented by UE.  Also, P-MPR is enough according to our simulation below.     1. UL metric calculation at gNB based on panel level P-MPR report 2. UL performance with full buffer traffic model for panel/beam switching  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | |  | Dense Urban | | | Indoor Hotspot | | | |  | Mean SE of cell | 5%SE | 50%SE | Mean SE of cell | 5%SE | 50%SE | | Case1 | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | | Case2 | 0.04% | -2.10% | -0.23% | -0.04% | 0.00% | 0.01% |  * + Case 1(baseline): when MPE event is declared by UE, a modified L1-RSRP is triggered. The UE reports the uplink RSRP that considers the impact of blockage and MPE power back-off for panel/beam switching. gNB selects and determines the panel/beam switching according to the reported uplink RSRP.   + Case 2: when MPE event is declared by UE, a Rel-15 L1-RSRP report is triggered by gNB. The UE reports 4 beam pairs between gNB and UE based on downlink RSRP that considers the impact of blockage. gNB selects and determines the panel/beam switching according to the reported DL RSRP and P-MPR. |
| LG | Do not support the proposal. The proposed method cannot report which panel/beam is good for UL transmission. |
| ZTE | Support in principle. We think that the beam-specific MPE should be clarified firstly, and then per DL RS(s) to be reported, the respective MPE values are provided.  Then, we think virtual PHR should be reported together. |
| Mod V18 | Revised. Please keep in mind this is a starting point as some companies have correctly understood so. |
| CMCC | Support. We think that DL RSRP should be reported. |
| Mod V20 | No revision from V18 |
| Sony | We are fine with Proposal 5.A.  Assuming L1 beam reporting cannot have consensus, we think the MAC layer signaling is our only remaining option. To mind the group that the P-MPR reporting in Rel.16 is not only P-MPR itself, but it also includes Pc,max and PH as captured as below. With such reporting (either per panel or per beam), NW is able to estimate which panel(s) or beam(s) would result in acceptable UL performance. This is already enhancement over Rel.16 RAN4’s solution which seems per serving cell (if my memory serves me right). Surely, we could start from ‘per panel’ MAC CE design due to its simplicity.  Machine generated alternative text: P R MPEorR PH（Type1，PCell) P CW'tA)(f,c Figure6·1·3·8·1：SingleEntryPHRMACCE |
| Mod V26 | No revision. Proposal is stable content-wise |

### Issue 6 (advanced beam refinement/tracking)

(Later rounds)

# References

|  |  |  |  |
| --- | --- | --- | --- |
| 1 | R1-2106864 | Summary of offline discussion on unified TCI and inter-cell beam management | Moderator (Samsung) |
| 2 | R1-2106463 | Enhancements on multi-beam operation in Rel-17 | Huawei, HiSilicon |
| 3 | R1-2106541 | Enhancements on Multi-beam Operation | ZTE |
| 4 | R1-2106571 | Further discussion on multi beam enhancement | vivo |
| 5 | R1-2106640 | Remaining Details on Enhancements for Multi-beam Operation | IDC, Inc. |
| 6 | R1-2106666 | Enhancements on Multi-beam Operation | Lenovo, Motorola Mobility |
| 7 | R1-2106685 | Enhancements on Multi-beam Operation | Spreadtrum Communications |
| 8 | R1-2106789 | Further enhancement on multi-beam operation | Sony |
| 9 | R1-2106864 | Moderator summary for multi-beam enhancement | Moderator (Samsung) |
| 10 | R1-2106865 | Multi-Beam Enhancements | Samsung |
| 11 | R1-2106935 | Discussions on enhancements on multi-beam operation | CATT |
| 12 | R1-2107029 | Enhancements on Multi-beam Operation | Fujitsu |
| 13 | R1-2107085 | Enhancement on multi-beam operation | FUTUREWEI |
| 14 | R1-2107143 | Discussion on multi-beam operation | NEC |
| 15 | R1-2107203 | Enhancements on Multi-beam Operation | OPPO |
| 16 | R1-2107297 | Discussion of enhancements on multi-beam operation | FGI, Asia Pacific Telecom |
| 17 | R1-2107323 | Enhancements on Multi-beam Operation | Qualcomm Incorporated |
| 18 | R1-2107390 | Enhancements on multi-beam operation | CMCC |
| 19 | R1-2107464 | Enhancements on multi-beam operation | Fraunhofer IIS, Fraunhofer HHI |
| 20 | R1-2107485 | Enhancement on multi-beam operation | MTK Inc. |
| 21 | R1-2107570 | Enhancements to Multi-Beam Operations | Intel Corporation |
| 22 | R1-2107628 | Enhancements on Multi-beam Operation | Ericsson |
| 23 | R1-2107689 | Enhancements on Multi-beam operations | AT&T |
| 24 | R1-2107718 | Views on Rel-17 Beam Management enhancement | Apple |
| 25 | R1-2107814 | Enhancements on Multi-beam Operation | LG Electronics |
| 26 | R1-2107838 | Discussion on multi-beam operation | NTT DOCOMO, INC. |
| 27 | R1-2107893 | Enhancements on multi-beam operation | Xiaomi |
| 28 | R1-2108019 | Enhancements on Multi-beam Operation | Convida Wireless |
| 29 | R1-2108052 | Enhancements on Multi-beam Operation | Nokia, Nokia Shanghai Bell |
| 30 | R1-2106548 | Further details on Multi-beam and Multi-TRP operation | ZTE |
| 31 | R1-2106671 | HARQ feedback of SPS PDSCH reception in multi-DCI based multiple TRPs | Lenovo, Motorola Mobility |
| 32 | R1-2106872 | Additional enhancements for multi-beam | Samsung |
| 33 | R1-2107210 | Discussion on further enhancements for multi-beam operation | OPPO |
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