**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 (other 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 (other than DMRS), NTT Docomo,  **Not support**: Lenovo/MotM (DMRS), Intel (DMRS), Huawei/HiSi, vivo, 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.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 (after 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, Xiaomi, ZTE, IDC, CATT, vivo, Futurewei, CMCC, Spreadtrum, Lenovo/MotM, NTT Docomo,  **Not support**: NTT Docomo, Ericsson, Fraunhofer IIS/HHI, Intel, Convida, AT&T, MTK, |

**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
  + Some CSI-RS resources for CSI
    - FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic
    - Note: This doesn’t imply that all time-domain behaviors are automatically supported
  + Some CSI-RS resources for BM
    - FFS: Discuss if/which restriction is necessary, e.g. only for aperiodic, repetition ‘ON’, apply to all resources in a set
    - Note: This doesn’t imply that all time-domain behaviors are automatically supported
  + DMRS(s) associated with non-UE-dedicated reception on PDSCH and all/subset of CORESETs

**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.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:

* 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.
* 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. 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

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.  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. |
| 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   **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” |
| 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   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 |
| 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.  **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?  **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. |
| 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   **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.  **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. |
| 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”.  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   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 |
| 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.  **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.  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. |

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

Table 3 Summary: issue 2

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| **#** | **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, 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]

**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 DL TCI and UL TCI are associated with a same cell

**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):

* Activation of TCI states for one cell is supported
* FFS: Whether >1 cells can be supported

**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 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

Table 4 Additional inputs: issue 2

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| **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.   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   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. |
| 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~~]~~   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.  **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.  **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.  **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?   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.  Proposal 2.A.5: We think it should be applicable not only for UE-dedicated channel but also for common channel. |
| MediaTek | Proposal 2.A.1: Support and suggest to remove the brackets and “some of the” in the sentence.  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.  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? |
| 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]   **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   **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”?  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.  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   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” |
| 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.  **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.  **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 |

### Issue 3 (beam indication signaling medium)

Table 5 Summary: issue 3

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| --- | --- | --- |
| **#** | **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. |

### 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

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. |
| 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. |
| 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. |
| 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. |

### 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

Table 10 Additional inputs: issue 5

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| --- | --- |
| **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 |
| 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. |

### 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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