**3GPP TSG RAN WG1 #106-e R1-2108361**

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

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary#3 for multi-beam enhancement: ROUND 2

**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:

|  |
| --- |
| 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

**Round 2 is intended to prepare the group for the 2nd GTW session (Friday 08/20 03:00 UTC toward the end). Please share your inputs by Friday 08/20 01:00 UTC.**

## 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)

|  |  |
| --- | --- |
| **Proposal** | **Companies’ views** |
| 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, Lenovo/MotM **Not support**: Intel, Huawei/HiSi, vivo, Futurewei, |
| 1.C (beam indication) | **Support**: MTK, Qualcomm, NTT Docomo, Sony, 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.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  |

**Proposal 1.B-3**: On Rel.17 unified TCI framework, for intra-cell beam indication, 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
	+ FFS: if the CORESET(s) is not 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.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

Table 2 Additional inputs: issue 1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 1 if needed****2) Share your inputs on the above FL proposals. In particular:*** **1.B-3: removed brackets (see MediaTek’s comment below), kept intra-cell per Huawei’s comment (note that issue 1 has been and is only for intra-cell)**
* **1.C: previous version was used but please engage with the proposal from Futurewei**
* **1.E: please respond to OPPO’s argument below**

 |
| OPPO | We still have concern on 1.E and do not see the justification to associate (P0, alpha, closed loop index) with each TCI state for SRS resource set. @ZTE: as in rel15/16, the (P0, alpha, closed loop index) is configured per SRS resource set, not per source. The reason is because the same PC shall be applied to all the SRS resource within one set. The PC configuration per SRS resource set is separate from that of PUSCH. We do support the SRS resource to use same closed loop index or different closed loop index as PUSCH. Here is the 213:For the SRS power control adjustment state for active UL BWP  of carrier  of serving cell  and SRS transmission occasion - , where  is the current PUSCH power control adjustment state as described in Clause 7.1.1, if *srs-PowerControlAdjustmentStates* indicates a same power control adjustment state for SRS transmissions and PUSCH transmissions; or-  if the UE is not configured for PUSCH transmissions on active UL BWP  of carrier  of serving cell , or if *srs-PowerControlAdjustmentStates* indicates separate power control adjustment states between SRS transmissions and PUSCH transmissions, and if *tpc-Accumulation* is not provided, where In our view, the rel15/16 rule shall be reused and unified TCI framework for MB shall not change the uplink power control operation.  |
| MediaTek | Proposal 1.B-3 means at least for the case if a CORESET is associated with both CSS set (non-UE-dedicated reception) and at least one USS set (UE-dedicated reception), the PDCCH receptions on this CORESET can share the same indicated Rel-17 TCI state. The intension is avoiding that one CORESET needs to apply different TCI (Rel-17 TCI + e.g., Rel-15/16 DL TCI) if the CORESET is associated with both CSS and USS. Note that R15/R16 DL TCI is indicated per CORESET, not per search space set. Compared with applying Rel-17 TCI to all non-UE-dedicated PDCCH receptions, this could be a compromise solution that still allows separate beam indications for non-UE dedicated reception and UE dedicated reception, respective, if NW would like to do so. |
| Futurewei | On Proposal 1.C, our understanding is that basically this is R17 mechanism using R17 TCI state but reuse R15/16 design.  So we would like to make the following modifications:**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), R17 mechanism(s) which reuse the Rel-15/16 TCI state update signaling/configuration design(s) are used to update/configure the Rel-17 TCI state. |
| NTT Docomo | Proposal 1.B-3: Support.Proposal 1.C: Support.Proposal 1.E: Support. Regarding to the OPPO’s concern, even if the setting of (P0, alpha, closed loop index) can be associated with TCI state, gNB can indicate the same setting across multiple SRS resources, if gNB wants to indicate the same parameters. So, we think gNB implementation can solve the issue. |
| ZTE | Proposal 1.B-3: Support. Just clarification, in our views, this rule can apply to both inter and intra-cell cases. But for progress, we are fine to agree it for intra-cell firstly.Proposal 1.C: Support. Proposal 1.D: Support.@OPPO, The separate closed loop is used for FDD (PUSCH-less) mainly, and can not be adjusted by DCI format 0\_0/1/2. It means that there exists Tx-power gaps between PUSCH and SRS for CB/NCB, regardless of gNB design. DCI overhead is an another issue. Then, how to achieve the uplink adaptation is a serious issue. In general, compared with Rel-15 design, we now prefer to have a really dynamic beam switch for UL and there are more than one activated UL TX beam. If we can dynamic switch PUSCH closed loop well, due to the same reason, we need to enhance SRS as well. At least, we need to have clear mechanism to achieve a goal that the **closed loop procedure for SRS is tied with the currently active PUSCH closed loop indicated by Rel-17 TCI**.  |
| vivo | Proposal 1.B-3:For DMRS(s) associated with non-UE-dedicated reception on CORESET(s) and the associated PDSCH, they are related to outcome of issue2. The behavior for inter-cell management should be clarified firstly.Proposal 1.C: Fine with the formulation from Futurewei. |
| Convida Wireless | We’re fine with the proposals. Some editorial suggestions:**Proposal 1.B-3**: …: * … if the CORESET(s) is associated with any USS set

FFS: if the CORESET(s) is not associated with any USS set**Proposal 1.E**: …FFS: Whether more than one parameter set~~s~~ can be configured, e.g. for different traffic types |
| OPPO2 | Considering some special specification on CORESET#0 defined in 213, we now have some concern on 1.B-3.According to the 213 specification, if a TCI state is indicated to CORESET#0, the CSI-RS contained in that TCI state must be QCLed with a SSB and that SSB is used by the UE to derive the monitoring occasions for Type0/0A/2-PDCCH CSS.Our concern on proposal 1.B-3 is: the indicated rel-17 TCI state might not meet this requirement. If the CSI-RS contained in rel-17 TCI state is not QCLed with a SSB, then how can the TCI state be applied to CORESET#0. |
| MediaTek  | Proposal 1.B-3: Support. We also fine to add restriction under Proposal 2.A.1to strictly align the WID, e.g., PDCCH reception associated with Type0/1/2 CSS set cannot be associated a CORESET if the if the CORESET is associated with any USS set, if this can address the concern on both Proposal 1.B-3 and Proposal 2.A.1. Re the comment from OPPO, we think Rel-15/16 DL TCI may also face the same situation but NW should avoid such configuration for CORESET#0, and Rel-17 TCI doesn't preclude to indicate a TCI sate includes a CSI-RS QCLed with SSB. Why this would be an issue for Rel-17 TCI and this proposal?Proposal 1.C: Support. We think the proposal already implies Rel-17 framework would reuse Rel-15/16 TCI state update signaling/configuration mechanism(s) to update/configure the Rel-17 TCI state, thus re-wording seems not needed.Proposal 1.E: Support and share same view with ZTE. |
| Apple | Proposal 1.B-3: For intra-cell BM, we do not see any reason to use separate beam indication for common signal and dedicated signal. However, separate beam indication would lead to different default beams. We think there are two options to handle the issue as follows. Option 1 would be a clean and simple version. For option 2, we assume the beam indication would not be applicable for Type0/1 CSS. Since usually connected mode UE does not need to receive SIB and RAR. Thus for SIB, it is still based on beam sweeping operation, and for RAR, it is based on the RACH beam as legacy approach. But after UE sends a RAR, there would be a potential case with 2 beams – one for RAR, the other for other signals. One way is to use the beam for RAR to receive all signals to avoid default beam collision similar to CORESET0, another way is to define a gap where UE does not receive anything else before it decodes RAR, but this would take too much overhead.**Option 1: Proposal 1.B-3**: On Rel.17 unified TCI framework, for intra-cell beam indication, 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

**Option 2: Proposal 1.B-3**: On Rel.17 unified TCI framework, for intra-cell beam indication, 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 Type2/3 CSS and USS and the associated PDSCH
* No additional beam indication mechanism for Type0/1 CSS
* After a CB-PRACH, the QCL and spatial relation assumption for the PDCCH/PDSCH/PUCCH/PUSCH and aperiodic CSI-RS across CCs at least within a band should be reset to be associated with the SSB associated with the CB-PRACH

  |

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

Table 3 Summary: issue 2 (from round 1)

|  |  |
| --- | --- |
| **Proposal** | **Companies’ views** |
| 2.A-1 (applicable channels) | **Support**: Ericsson, Samsung, Qualcomm, Apple, MTK, NTT Docomo, AT&T, Spreadtrum, Lenovo/MotM, OPPO, Xiaomi, CATT, ZTE, CMCC, Sony, Nokia/NSB, Futurewei, FGI/APT, **Not support**: vivo, Huawei/HiSi,  |
| 2.A-3 (multiple cells) | **Support**: Ericsson, Samsung, Qualcomm, MTK, NTT Docomo, AT&T, Spreadtrum, Lenovo/MotM, OPPO, Xiaomi, CATT, ZTE, CMCC, Sony, Nokia/NSB, Futurewei, FGI/APT, **Not support**: vivo |
| 2.A-5 (indirect QCL) | **Support**: Ericsson, Samsung, Qualcomm, Intel, Apple (together with 2.A-1, keep ‘at leas’), MTK (keep ‘at least’), NTT Docomo, AT&T, Spreadtrum, Lenovo/MotM, OPPO, Xiaomi, CATT, LG, ZTE, CMCC, Sony, Nokia/NSB, Futurewei, FGI/APT, **Not support**: vivo (delete ‘at least’),  |

**Proposal 2.A.1**: On Rel.17 beam indication enhancements for inter-cell management, the supported 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) applies to:

* The same channels as for intra-cell beam management configured to the same cell

**Proposal 2.A.3**: On Rel.17 beam indication enhancements for inter-cell management, for the supported 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):

* 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
* Note: If UE reporting supports one physical cell ID, the NW can activate TCI states associated with either a serving cell or a non-serving cell

**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) Check and update Table 1 if needed****2) Share your inputs on the above FL proposals. In particular:*** **2.A-1: please respond to Huawei’s and vivo’s comments**
* **2.A-3: previous version was used with Docomo’s note**
* **2.A-5: previous version was used (‘at least’ is kept)**
 |
| vivo | 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). |
| Huawei/HiSi | **Proposal 2.A.1:** First, according to the response from Darcy, we suggest changing “the same cell” as “the unchanged serving cell”. Assuming Proposal 1.B-3 for intra-cell case is agreed, it is still unclear to us whether Proposal 2.A.1 would ask the UE to receive system information from a cell with a PCI that is different from the serving cell. If the answer is yes, then this goes directly against the WID updated in RAN#92-e. If the answer is no, then the non-UE-dedicated channels should not be included in the proposal |
| NTT Docomo | Proposal 2.A.1: Support. But, we are not sure what “configured to the same cell” intends. If we remove it, we can understand what the proposal means, so we feel this part can be removed.Proposal 2.A.3: Support.Proposal 2.A.5: Support. |
| ZTE | Proposal 2A.1: Firstly, we can not live with the description of ‘the unchanged serving cell’. In our views, the intention of this proposal is align the same solution for between intra-cell and inter-cell mobility. If revised to ‘unchanged serving cell’, it seems that we come back to the proposal 1.B-3. As a compromise, we are fine to use the wording as in RAN2 LS like ‘inter-TRP with different PCI’. Then, we are fine with Huawei’s suggestion that UE may not decode the SIB message from the TRP/cell with different PCI.Proposal 2.A.3, after double thinking, it may be relevant to on-going discussion in 8.1.2.2. So, we suggest to wait for the conclusion/agreement in 8.1.2.2Proposal 2.A.5, ‘at least for UE-dedicated PDSCH and UE-dedicated PDCCH’ is unclear. May I assume to use the same wording in Proposal 2.A.1, like ‘for the same channels as for intra-cell beam management configured to the same cell’. Then, we prefer to consider direct QCL reference herein.  |
| Sony | Proposal 2.A.3: we are okay with the direction. We just would like to ask a clarification question regarding the ‘note’. That is if UE reports only 1 cell can be associated with active TCI state(s), should the cell be serving cell, rather than a non-serving cell? If not, NW can only activate TCI states associated with non-serving cell, but not the serving cell. This seems not the intention of the proposal here. Perhaps I get something wrong, please let me know, if any. Thanks in advance. |
| Convida Wireless | Fine with the proposals, but an editorial suggestion: “On Rel.17 beam indication enhancements for inter-cell beam management” |
| OPPO | Considering the CORESET#0, we realize that proposal 2.A.1 might not work if it requires the rel-17 indicated TCI state to apply on all CORESET#0.The reason is that as specified in 213, when a CORESET#0 is indicated with a TCI state, the CSI-RS resource in that TCI state must be QCLed with a SSB and the UE use that SSB to derive the monitoring occasions for PDCCH candidate of Type0/0A/2 CSS. Apparently, in rel-17 inter-cell BM, the UE can not be provided with a TCI state with a CSI-RS QCLed to non-serving cell SSB to the CORESET#0 because the UE is not able to derive CSS monitoring occasions based on any SSB associated with a PCID that is different from that of the serving cell.Prefer to change it as follows to preclude the CORESET#0:**Proposal 2.A.1**: On Rel.17 beam indication enhancements for inter-cell management, the supported 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) applies to:* The same channels as for intra-cell beam management configured to the same cell
* CORESET#0 is not included here.
 |
| MediaTek | Proposal 2.A.1: Support. According to the latest Proposal 1.B-3, this will not conflict with Scenario 1 agreed in RAN2. We also fine to add restriction under Proposal 2.A.1to strictly align the WID, e.g., PDCCH reception associated with Type0/1/2 CSS set cannot be associated a CORESET if the if the CORESET is associated with any USS set, if this can address the concern on both Proposal 1.B-3 and Proposal 2.A.1. Proposal 2.A.3: Support with minor change to align the wordings of the first and second bullet.* Note: If UE reporting supports one physical cell ID, the NW can activate TCI states associated with a physical cell ID either the same as or different from that of the serving cell

Re the question from Sony: We think NW can activate TCI states associated with only one non-serving cell for the channels included in Rel.17 beam indication enhancements for inter-cell management (i.e., according to Proposal 2.A.1). For other channels not included, NW can activate TCI states associated with the serving cell based on Rel-15/16 mechanism. Proposal 2.A.5: Support |
| Apple | Proposal 2.A.1: Response to vivo and Huawei: RAN reverted this agreement and define the WID as follows:* + 1. 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

If current proposal is not agreeable, we suggest we think about option 2 from proposal 1.B-3 we proposed above.Proposal 2.A.5: Maybe this can be reformulated as follows to avoid the dedicated vs common discussion.**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 can be indicated as the QCL source of the periodic TRS based on legacy QCL rule |

### Issue 3 (beam indication signaling medium)

Round 3

### Issue 4 (MP-UE)

Round 3

### Issue 5 (MPE mitigation)

Round 3

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

Round 3

# 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 |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |