**3GPP TSG RAN WG1 #106-e R1-210xxxx**

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

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

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

**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
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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 – note: for intra-cell beam management)

Table 1 Summary: issue 1

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| --- | --- |
| FL proposal 1.E (UL PC for SRS)Note: Already discussed since round 0 | **Support**: Apple, MTK, Qualcomm, Lenovo/MotM, NTT Docomo, FGI/APT, Ericsson, Samsung, Intel, ZTE, Convida, CATT, vivo, Futurewei, Spreadtrum, AT&T, NTT Docomo, LG**Not support**: OPPO |
| FL proposal 1.F (M,N>1)Note: Already discussed since round 0 | **Support**: Qualcomm, Lenovo/MotM, FGI/APT, Samsung, ZTE, IDC, CATT, vivo, Futurewei, Lenovo/MotM, AT&T, LG**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 |
| Finalizing UL PC parameters other than PL-RS:Whether to configure the same setting of (P0, alpha, closed loop index) per TCI state across channels and apply a channel dependent component, or not (i.e. configure a channel dependent setting of (P0, alpha, closed loop index) per TCI state)Note: It was agreed (RAN1#105-e) to finalize this in RAN1#106-e | **Yes**: Samsung, LGE, NTT Docomo**No:** ZTE, vivo, OPPO, MTK, Intel, Ericsson, IDC,CATT |

**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

**Proposal 1.G**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, a channel/signal dependent setting of (P0, alpha, closed loop index) per TCI state is configured for each of the applicable UL channels and signals.

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** |
| Qualcomm | For Proposal 1.E-1.G, support |
| Samsung | **Proposal 1.E**: Support**Proposal 1.F**: Support**Proposal 1.G**: Don’t support.In the unified TCI framework, a common beam is used for the uplink channels (e.g. PUSCH and PUCCH), therefore it seems natural that the TCI state dependent component of a power control parameter is common across all channels. On top of that there is a channel dependent component that can be applied but that is beam independent. Having a channel dependent/TCI state dependent setting of the power control parameters increases configuratuion overhead and is not technically justified.We suggest the following update:**Proposal 1.G**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, a channel/signal independent setting of (P0, alpha, closed loop index) per TCI state is configured ~~for each of the applicable UL channels and signals~~, in addition to the previously agreed channel dependent setting. |
| OPPO | **Proposal 1.E:** do not support**.** What we have agreed on PC parameters for PUSCH, PUCCH and SRS are enough. Additional design is not needed.The design we have agreed yet follows exactally the same design as in rel16. Whatever people want to support can be supported without needing any additional design.**Proposal 1.F:**  In our view, we only see clear use case for (M,N) = (2,2) for m-DCI based mTRP. For other scenarios, there is not clear use cases. SO we are only fine to agree on (M,N) = (2,2) for m-DCI based mTRP and FFS all the other combnation of M and N and other use cases.**Proposal 1.G:** Support but suggest to clarify that it is for PUSCH and PUCCH by the following wording change:**Proposal 1.G**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, a channel/signal dependent setting of (P0, alpha, closed loop index) per TCI state is configured for ~~each of the applicable UL channels and signals~~ PUSCH and PUCCH. |
| Lenovo/MotM | **Proposal 1.E:** Support**Proposal 1.F:** Support**Proposal 1.G:** Do not support. It shall be sufficient to configure separate parameter sets for PUCCH, for PUSCH, and SRS. There is no need to configure different parameters for different PUCCH channels, or for different PUSCH channels, or SRS. We propose to change it from per channel/signal to per channel/signal type. **Proposal 1.G**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, ~~a channel/signal dependent~~ separate settings of (P0, alpha, closed loop index) per TCI state ~~is~~ are configured for ~~each of the applicable UL channels and signal types~~ PUCCH, PUSCH, and SRS. |
| Apple | **Proposal 1.E**: Support**Proposal 1.F**: Do not support. It seems based on current WA on beam indication for “any other DL RS” and agreements for intra-cell/inter-cell BM, M>1, N>1 is already precluded.**Proposal 1.G**: Support  |
| MediaTek | **Proposal 1.E**: Support**Proposal 1.F**: Not support. Similar with OPPO, we have strong concern to agree something w/o clear use cases at this stage. We can compromise to support M,N values other than (1,1) only of mTRP.**Proposal 1.G:** Support. In order to avoid discussing which parameter is channel dependent/independent, it is much easier to leave the configuration flexibility to NW. |
| ZTE | **Proposal 1.E**: Support. Regarding OPPO’s comments, in our views, unified TCI state is supposed to be dynamically indicated for SRS with the same Tx beam as PUSCH (which is different from legacy/typical Rel-15/16 framework), 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. In our intial views, (2, 2) refers to mDCI-mTRP, and (2, 1) refers sDCI-mTR. But, the usage of (1, 2) should be justified.**Proposal 1.G:** Support, but it seems that Lenovo/MotM’s version looks much clear. |
| InterDigital | **Proposal 1.E**: Support**Proposal 1.F**: Support. Responding to OPPO, we only support the Proposal 1.F when equally capturing both mTRP and sTRP use cases as in the current form of FL’s proposal. At least, the listed use cases for sTRP in the FL’s proposal are all solid use cases and have been discussed so far among many companies including us. So, we failed to understand why just insisting they are not clear at this late stage. I believe the current form of Proposal 1.F is the only way to move forward for progress, as this has already been intensively discussed and no need to be arguing hard on FFS points, either, as they are FFS.**Proposal 1.G**: Do not support. Similar view as Samsung. |
| LG | **Proposal 1.E**: Support**Proposal 1.F**: Support**Proposal 1.G:** Not support. We have a same view with Samsung that the channel-common PC parameters to be associated with UL/joint TCI is quite beneficial to reduce the signaling overhead on TCI state configuration based on the common UL beam opearation in the unified TCI framework we’ve designed.On Samsung’s suggestion, we prefer to slightly change the wording (yellow-marked):**Proposal 1.G**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, a channel/signal ~~independent~~common setting of (P0, alpha, closed loop index) per TCI state is configured ~~for each of the applicable UL channels and signals~~, in addition to the previously agreed channel dependent setting. |
| CMCC | **Proposal 1.E**: Support**Proposal 1.F**: Do not support. sTRP use case is not clear to us. We are also fine to discuss M, N>1 in Rel-18**Proposal 1.G**: Support |

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

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.3 | Maximum value of K (beams associated at least with non-serving cell(s) reported in a single CSI reporting instance), i.e. KMAX beyond 4 (already agreed)Note: UE capability of supporting < KMAX is neither ruled out nor within the scope  | **8**: Ericsson, Nokia/NSB, AT&T, CATT**16**: Samsung, Huawei/HiSi, CATT, ZTE |
| 2.4 | How to set the value of K≤ KMAXAlt1: RRC configured (based on UE capability)Alt2: Dynamically selected by UE (indicated in CSI reporting, two-part UCI) | **Alt1**: Lenovo/MotM, Ericsson, ZTE,CATT**Alt2**: Samsung  |
| 2.5 | The maximum value of NMAX (number of RRC configured non-serving cell(s) for measurement/reporting) Note: UE capability of supporting <Nmax is neither ruled out nor within the scope of 2.4 | **1**: OPPO**2**: Lenovo/MotM **4**: Samsung**KMAX**: AT&T, CATT, Ericsson, ZTE, Samsung  |
| 2.7 | Whether to support event-driven reporting behaviorNote: For beam reporting, revised WID has ruled out L3 involvement | **Yes, with L1 event**: Xiaomi, Nokia/NSB, Samsung, Sony, Qualcomm, Apple, LG, [Intel], [CATT]**Yes, with L3 event**: Xiaomi, ZTE, [Intel], [CATT] **No**: Ericsson, MTK |
| 2.8 | Synchronization and timing advance assumptions between cellsNote: This issue was identified in RAN#92 and needs to be concluded in RAN1#106-e | **Single TA value across cells (TRPs with different PCIs)**: OPPO, MTK **Multiple TA values across cells (TRPs with different PCIs)**: vivo, Futurewei, Qualcomm, Intel, Ericsson, Apple, NTT Docomo, Samsung, Sony, ZTE |
|  |  |  |

**Proposal 2.C**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, also support KMAX = 8.

* Note: KMAX is defined as the maximum number of beams associated at least with TRP(s) with different PCIs from the serving cell that are reported in a single CSI reporting instance

**Proposal 2.D**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, for a given UE capability of KMAX, the value of K≤ KMAX is RRC configured

* Note: K is defined as the number of beams associated at least with TRP(s) with different PCIs from the serving cell that are reported in a single CSI reporting instance
* Note: KMAX is defined as the maximum number of beams associated at least with TRP(s) with different PCIs from the serving cell that are reported in a single CSI reporting instance

**Proposal 2.E**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, NMAX (the maximum number of RRC configured TRP(s) with different PCIs from the serving cell for measurement/reporting) is equal to KMAX.

**Proposal 2.F**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, in RAN1#106bis-e, select one of the following alternatives:

* Alt1. Support L1-based event-driven beam reporting for inter-cell beam management and inter-cell mTRP
* Alt2. Support L3-based event-driven beam reporting for inter-cell beam management and inter-cell mTRP
* Alt3. In Rel-17, event-driven beam reporting is not supported for inter-cell beam management and inter-cell mTRP

**Proposal 2.G**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, multiple TA values across TRPs with different PCIs from that of the serving cell are supported.

Table 4 Additional inputs: issue 2

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| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 3 if needed****2) Share your inputs on the above FL proposals** |
| Qualcomm | For Proposal 2.C, 2.D, 2.E, suggest the following wording based on 105e agreement. Otherwise, it may imply a serving cell can have different PCIs.* Note: KMAX is defined as the maximum number of beams associated at least with non-serving cell(s) ~~TRP(s) with different PCIs from the serving cell that are~~ reported in a single CSI reporting instance

For Prooposal 2.E, in addition to the above wording, suggest the following change. Because Kmax is the total reported beams per report, and UE supporting Kmax does not mean UE can measure beams from Kmax different PCIs. The # of measured PCIs should be a separate UE capability from Kmax.**Proposal 2.E**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, NMAX (the maximum number of RRC configured TRP(s) with different PCIs from the serving cell for measurement/reporting) is ≤ ~~equal to~~ KMAX and is up to UE capability with candidate value at least includes 1.For Proposal 2.F, support and prefer Alt1. Btw, isn’t L3 based measurement already excluded from revised WID?For Proposal 2.G, support at least for inter-cell BM. We understand inter-cell mTRP already agreed to have DL Rx timing < CP to facilitate simultaneous Rx. So asking different TAs might be a bit unnecessary. But different TAs are highly beneficial for inter-cell BM, which is target for mobility with single TRP operation. Otherwise, we don’t see any fundamental benefit for inter-cell BM compared with inter-cell mTRP, which can even do simultaneous Rx.**Proposal 2.G**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management ~~and inter-cell mTRP~~, multiple TA values across TRPs with different PCIs from that of the serving cell are supported. |
| Samsung | **Proposal 2.C:** Support with changes. In addition to KMAX = 8, support KMAX = 16. As a compromise, we propse to add FFS for KMAX = 16.**Proposal 2.C**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, also support KMAX = 8.* **FFS: KMAX = 16**
* Note: KMAX is defined as the maximum number of beams associated at least with TRP(s) with different PCIs from the serving cell that are reported in a single CSI reporting instance

**Propsoal 2.D:** Don’t supportThe value of K can be determined by the UE based on the current conditions and reported in the beam report. For example, a two-part beam report can include K and a subset of beam information in the first part and the remaining beam information in the second part. Having K configure by the network could lead to the network configuring a large value e.g. KMAX which is not always needed, this leads to unnecessary increase in UE computation complexity. On the otherhand if KMAX is configured small, this could lead to under reporting of the number of beams.**Proposal 2.D**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, for a given UE capability of KMAX, the value of K≤ KMAX is ~~RRC configured~~ determined and reported by the UE.* Note: K is defined as the number of beams associated at least with TRP(s) with different PCIs from the serving cell that are reported in a single CSI reporting instance
* Note: KMAX is defined as the maximum number of beams associated at least with TRP(s) with different PCIs from the serving cell that are reported in a single CSI reporting instance

**Proposal 2.E:** OK**Proposal 2.F:** OK in principle as we are downselecting in the next meeting. We would like more clarity on Alt2, two questions we have: Will this be by MAC CE signaling or RRC signaling? Will this require RAN2 involvement? We are concerned with any solution that requires RRC/MAC CE signaling of the beam report or RAN2 involvement due to limited TUs available in RAN2 for this feature.**Proposal 2.G:** Don’t supportWhile we see the benefit of supporting multiple TAs, we think that this is better handled in Rel-18 given the limited time available in Rel-17. |
| OPPO | On proposal 2.C: why Kmax must be 8? What is the use case for such large number? In current L1-RSRP measurement and reporting, Kmax = 4. If K = 4 for one serving cell is sufficient, why K = 4 is not sufficient for one non-serving cell?One proposal 2.D: Support. The value of K shall be RRC-configured and UE reports the ‘best’ K.On Proposal 2.E: we do not think more than one different PCIs shall be configured in RRC for beam measurement and reporting. The non-serving cell selection shall be done through the exsiting RRM and the L1-RSRP measurement is only used to find the best beams of the selected non-serving cell TRP. Suggest to make the following changes:**Proposal 2.E**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, NMAX (the maximum number of RRC configured TRP(s) with different PCIs from the serving cell for measurement/reporting) is equal to 1 ~~K~~~~MAX~~.One proposal 2.F: okOne proposal 2.G: do not support. As stated in revised WID, this work assumes intra-DU only. Due to that, in our view, we shall assume that the TA across TRPs are well maintained and no extra specification support is needed. |
| Lenovo/MotM | Proposal 2.C: Do not support. Kmax=4 is sufficient for a CSI report. Proposal 2.D: Support.Proposal 2.E: Do not support. Since KMAX is defined as the number in a CSI report, our understanding of NMAX is also for a CSI report. NMAX=2 is sufficient for a CSI report. More non-serving cells can be configured withmore CSI-ReportConfig. Proposal 2.F: Do not support. Given there is only 1 meeting left for R17, it is best to leave this to R18.  |
| Apple | Proposal 2.C: We suggest we first check how many cells can be configured for L1-RSRP measurement to see whether Kmax=8 is valid or not. If only 2 cells, it would be similar to mTRP, where Kmax is still 4.Proposal 2.D: We do not think this is needed.Proposal 2.E: We are ok in general, but we think Alt2 should be removed, since only L1 measurement has been supported Proposal 2.F: Since currently scenario of inter-cell BM is similar to inter-cell TRP, we think a single TA is enough. |
| MediaTek | **Proposal 2.C:** Not support but we can compromise to only the case if measurement RS reosurces of a beam reporting are assoiated with more than one PCIs. Otherwise, we don't see the need to support more than four. **Proposal 2.C**: On Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for inter-cell beam management and inter-cell mTRP, also support KMAX = 8 only if the measurement RS reosurces of a beam reporting are assoiated with more than one PCIs* Note: KMAX is defined as the maximum number of beams associated at least with TRP(s) with different PCIs from the serving cell that are reported in a single CSI reporting instance

**Proposal 2.D:** This proposal is not needed since it is already agreed according to the following agreement made in RAN1#105e meeting.AgreementOn Rel.17 L1-RSRP multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,* Support at least K=4, where K is defined as the number of beams associated at least with non-serving cell(s) reported in a single CSI reporting instance
	+ The maximum value of supported K is a UE capability
	+ K is configured by NW based on the UE capability
	+ FFS: The support of K=8 and 16
		- For K>4, the maximum number of beams associated with one cell is 4
* FFS: Support L1-based event-driven reporting based on Rel-16 SCell BFR framework or analogous to L3-based event-driven reporting, including the definition of L1-based event, if needed

Note: If another beam metric other than L1-RSRP is supported (e.g. L3-RSRP is still FFS), the above also applies**Proposal 2.E:** We can support more than 1 since mixed measurement/reporting on serving and non-serving cell is agreed, but we don't see the need to support more than 2, i.e., NMAX <= 2. A corresponding UE capability is also needed.**Proposal 2.F:** Share the same view with QC. Alt2 should be precluded from RAN1 discussion due to revised WID.**Proposal 2.G:** Not support. Prefer to handle it in the next release. |
| ZTE | **Proposal 2.C:** Support in principle. From gNB vendor, we do identify the necessary of increase the maximm number of Tx beams to be reported in a report instance. So KMAX=16 is our preference, but for progress, we can live with KMAX=8.**Proposal 2.D:** Support. But we are open to consider the case raised by Samsung.**Proposal 2.E**: One question for clarification: for this NMAX, it is configured by gNB or implicitly determined by UE, e.g., through indicating Tx beam from same or different TRPs by UE? **Proposal 2.F:** Support. But we slightly prefer to make decision this meeting, considering that only two meetings are left.  |
| LG | **Proposal 2.C:** Agree with OPPO, the use case of Kmax=8 is not clear for us.**Proposal 2.D:** OK since this is the same as legacy.**Proposal 2.E:** Not OK, Kmax and max number of PCIs are not relavant.**Proposal 2.F:** To our understanding, Alt2 is not within RAN1 work scope. So, it should be precluded.**Proposal 2.G:** Technically, we are supportive on different TA across different TRPs but after checking with our RAN2 colleague, it requires quite large impact on RAN2 as well as RAN1. So we prefer to handle this in Rel-18. |
| CMCC | **Proposal 2.C:** Support. MTK’s version is also fine to us.**Proposal 2.D:** Agree with Apple and MTK, the proposal is not needed.**Proposal 2.E:** Support.**Proposal 2.**F: We prefer to Alt 3. Event-driven beam reporting can be considered in Rel-18.**Proposal 2.G:** Support. |

### Issue 3 (beam indication signaling medium)

(no more for this meeting)

### Issue 4 (MP-UE)

Table 5 Summary: issue 4

|  |  |
| --- | --- |
| FL proposal 4.A V1  | **Support/ok**: LG, Ericsson, OPPO, CATT, IDC, **Not support/concern**: MTK, Apple, NTT Docomo, Qualcomm, Samsung, Intel, Lenovo/MotM, Xiaomi, ZTE, Huawei/HiSi, CMCC,  |
| FL proposal 4.A V2 | **Support/ok**: LG, Sony, **Not support/concern**: Ericsson,  |

**Proposal 4.A V1**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection:

* No additional specification enhancement on CSI/beam reporting to facilitate UE-initiated panel activation/selection (i.e. Opt1-3 per RAN1#104-bis-e agreement)
* Support multiple codebook-based SRS resource sets with different maximum number of UL MIMO layers
	+ FFS: Whether/how the selection of SRS resource for codebook-based PUSCH transmission is controlled by UE.

OR

**Proposal 4.A V2**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection:

* A panel entity corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance (i.e. Opt1-1 per RAN1#104-bis-e agreement)
	+ The correspondence between a panel entity and a reported CSI-RS and/or SSB resource index is informed to NW
	+ Note: the correspondence between a CSI-RS and/or SSB resource index and a panel entity is determined by the UE (analogous to Rel-15/16)
* Support multiple codebook-based SRS resource sets with different maximum number of UL MIMO layers
	+ FFS: Whether/how the selection of SRS resource for codebook-based PUSCH transmission is controlled by UE.

Table 6 Additional inputs: issue 4

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| **Company** | **Input** |
| Mod V0 | **Check and update Table 5 if needed based on the two alternative proposals (4.A V1 vs 4.A V2).**  |
| Qualcomm | Support V2 with the following change. We are fine to use SRS resource set as implicit panel ID. Without such association, Gnb does not know which panel is used and corresponding supported layers. We don’t think V1 is a working proposal. * A panel entity refers to an SRS resource set ID, which corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance (i.e. Opt1-1 per RAN1#104-bis-e agreement)
 |
| Samsung | Support V.2 |
| OPPO | Do not support V.2. Support V.1 with the following wording change:**Proposal 4.A V1**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection:* No additional specification enhancement on CSI/beam reporting to facilitate UE-initiated panel activation/selection (i.e. Opt1-3 per RAN1#104-bis-e agreement)
* Support multiple codebook-based SRS resource sets with different maximum number of UL MIMO layers
	+ FFS: Whether/how the selection of SRS resource set for codebook-based PUSCH transmission is controlled by UE.
 |
| Lenovo/MotM | Support V.2 |
| Apple | Support a modified V.2 as follows:**Proposal 4.A V2**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection:* A panel entity corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance (i.e. Opt1-1 per RAN1#104-bis-e agreement)
	+ The correspondence between a panel entity and a reported CSI-RS and/or SSB resource index is informed to NW
	+ Note: the correspondence between a CSI-RS and/or SSB resource index and a panel entity is determined by the UE (analogous to Rel-15/16)
* Support UE reports maximum number of SRS ports for each panel entity
* Support multiple codebook-based SRS resource sets with different maximum number of UL MIMO layers
	+ The indicated SRI is based on the SRS resources corresponding to one SRS resource set, where the SRS resource set should be aligned with the UE capability for the panel entity
 |
| MediaTek | Support V.2. However, thought the panel entity, it is unclear how NW know which SRS set should be triggered when it is going to use a Gnb beam (corresponding to a reported SSBRI/CRI) to receive the CB-based SRS. We think some information must be implicitly/explicitly conveyed by the panel entity, as idenetified in the previous agreement. Thus, we see Apple’s suggestion is needed. |
| ZTE | Support V.2. Apple’s update looks good for us, but for moving forward this issue, we can live with this FL proposal without any modification. The remaining issue can be handled next meeting. We do need a decision right now. |
| InterDigital | Support V.2. We can also support Apple’s update. |
| LG | Support V.2We tried to compromise to V.1 but based on yesterday’s comment from Ericsson, if V.1 is changed to block all UE reporting including UE capability reporting, the intended functionality of the second bullet (i.e. supporting different number of ports across different panels) cannot be supported at all. How Gnb can configure 4 ports and 2 ports in different SRS resource sets without any information from UE? We cannot accept V.1 if it is modified such way. We are also fine with Apple’s suggestion on V.2 |
| CMCC | We prefer Opt1-2 per RAN1#104-bis-e agreement. But for progress, we can accept V2 with adding the highlighted FFS based on Apple’s version:**Proposal 4.A V2**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection:* A panel entity corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance (i.e. Opt1-1 per RAN1#104-bis-e agreement)
	+ The correspondence between a panel entity and a reported CSI-RS and/or SSB resource index is informed to NW
	+ FFS: The detailed design of how to inform NW the correspondence
	+ Note: the correspondence between a CSI-RS and/or SSB resource index and a panel entity is determined by the UE (analogous to Rel-15/16)
* Support UE reports maximum number of SRS ports for each panel entity
* Support multiple codebook-based SRS resource sets with different maximum number of UL MIMO layers
	+ The indicated SRI is based on the SRS resources corresponding to one SRS resource set, where the SRS resource set should be aligned with the UE capability for the panel entity
 |

### Issue 5 (MPE mitigation)

Table 7 Summary: issue 5

|  |  |
| --- | --- |
| **Proposal** | **Companies’ views** |
| 5.A below | **Support:** Qualcomm, NTT Docomo, Spreadtrum, Lenovo/MotM, Xiaomi, vivo, ZTE, CMCC, Sony, Nokia/NSB, Samsung, MTK, Apple, Intel (Alt1), Huawei/HiSi, LG, IDC**Not support:** Ericsson, CATT (add L1-SINR), OPPO (add vPHR, remove Alt2), [Intel], Convida,  |

**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
	+ The N P-MPR values are reported together with one of the followings (to be finalized in RAN1#106bis-e):
		- Alt1: For each P-MPR value, up to M SSBRI(s)/CRI(s), where the SSBRI(s)/CRI(s) is selected by the UE from a candidate SSB/CSI-RS resource pool (FFS: how to perform the selection)
		- Alt2: For each P-MPR value, at least one panel entity indicator
* FFS: Whether N represents the number of selected beams or the number of panels
* FFS: Supported values of N
* 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
* FFS: additional signaling (e.g. CSI triggering) from the NW

Table 8 Additional inputs: issue 5

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 7 if needed** **2) Share your inputs on the above FL proposal (new argument, please don’t repeat the old arguments)** |
| Qualcomm | For Proposal 5.A, both of the following two alternatives seem associate the P-MPR with the panel, i.e. Alt1 reports a panel specific P-MPR with corresponding multiple UL beams, while Alt2 reports P-MPR associated with a panel ID. We don’t think we need to tie the P-MPR report to panel. Whether beam or panel is already captured in a following FFS. So we suggest remove the two alternatives, since both imply P-MPR report is related to panel, which is not necessary to the MPE feature to our understanding.* + ~~The N P-MPR values are reported together with one of the followings (to be finalized in RAN1#106bis-e):~~
		- ~~Alt1: For each P-MPR value, up to M SSBRI(s)/CRI(s), where the SSBRI(s)/CRI(s) is selected by the UE from a candidate SSB/CSI-RS resource pool (FFS: how to perform the selection)~~
		- ~~Alt2: For each P-MPR value, at least one panel entity indicator~~
 |
| Samsung | Support for progress, although our preference is Alt1Clarification comment: what does “up to M SSBRI(s)/CRI(s), where the SSBRI(s)/CRI(s) is selected…” mean? |
| OPPO | Since the current proposal is based on Opt 1D in previous agreement, we prefer to use the same wording as in previous agreement.* Opt 1D. {Rel.16 P-MPR based (beam/panel-level)}
	+ The reporting reuses the event-driven mechanisms from the Rel-16 P-MPR reporting

Therefore, we suggest to change wording of Alt1 as follows:**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
	+ The N P-MPR values are reported together with one of the followings (to be finalized in RAN1#106bis-e):
		- Alt1: For each P-MPR value, up to M ~~SSBRI(s)/CRI(s)~~ UL beam indexes, where the ~~SSBRI(s)/CRI(s)~~ UL beam index is selected by the UE from a candidate ~~SSB/CSI-RS resource~~ UL beam pool (FFS: how to perform the selection)
		- Alt2: For each P-MPR value, at least one panel entity indicator
* FFS: Whether N represents the number of selected beams or the number of panels
* FFS: Supported values of N
* 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, TCI state Index,
* FFS: additional signaling (e.g. CSI triggering) from the NW
 |
| Apple | We do not quite understand QC’s comments, but we worried if we use current formulation and without consensus for the down-selection at next meeting, we would only have N>=1 P-MPR without any interpretation.So our suggestion is to directly select Alt1. It seems majority of companies are ok with Alt1 from last rounds comment.  |
| ZTE | Support in principle. It depends on the progress of Issue4. If, unfortunately, we can not have agreement for introducing a panel ID, we suggest to remove Alt2 directly; otherwise, we can are fine with this proposal.A general comments, there are existing MPE field(s) in current Rel-16 PHR MAC-CE that just corresponds to the currently serving beam, and so the following modification:**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):* In addition to the existing field in the PHR MAC-CE, N≥1 P-MPR values can be further reported
	+ The N P-MPR values are reported together with one of the followings (to be finalized in RAN1#106bis-e):
		- Alt1: For each P-MPR value, up to M SSBRI(s)/CRI(s), where the SSBRI(s)/CRI(s) is selected by the UE from a candidate SSB/CSI-RS resource pool (FFS: how to perform the selection)
		- Alt2: For each P-MPR value, at least one panel entity indicator
* FFS: Whether N represents the number of selected beams or the number of panels
* FFS: Supported values of N
* 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
* FFS: additional signaling (e.g. CSI triggering) from the NW
 |
| InterDigital | Support Proposal 5.A. Responding to OPPO’s comment, we prefer the current FL’s description on Alt1 having “SSBRI(s)/CRI(s)”, as it’s clear and so far largely supported by many companies. Changing to “UL beam indexes” is not clear to us, and no need to be one-step back without outstanding benefits at this stage. BTW, a previously removed sub-bullet under Alt.1 as “Support at least M=1, and FFS on M>1” should be added back under Alt.1, since currently a possible value range of M is missing. Although we understand discussions on M>1 can be separately handled, the possible value range of M needs to be anyhow mentioned here.  |
| LG | Support the proposal. |

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

Table 9 Summary: issue 6

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| --- | --- | --- |
| **#** | **Issue** | **Companies’ views on specific candidate schemes** |
| 6.1 | Group 1: Beam management with reduced DL signaling to reduce latency* Opt 1-A. UE-initiated beam selection/activation based on beam measurement and/or reporting (without beam indication or activation from NW)
* Opt 1-B. Beam measurement/reporting/refinement/selection triggered by beam indication (without CSI request)
* Opt 1-C. Aperiodic beam measurement/reporting based on multiple resource sets for reducing beam measurement latency
 | **Opt 1-A**: ZTE, vivo, Futurewei, OPPO, Qualcomm, MTK, Ericsson, Apple, LGE, NTT Docomo, Nokia/NSB, IDC (only within an indicated TCI state group, e.g., by a group-ID)**Opt 1-B**: ZTE, IDC, Samsung, Qualcomm, OPPO**Opt 1-C**: ZTE, CATT, Qualcomm, Samsung |
| 6.2 | Group 2: Reducing activation delay of TCI states and PL-RSs (including other WGs, e.g. RAN4)* Opt 2-A: Latency reduction for MAC CE based TCI state activation, or frequency/time/beam tracking
* Opt 2-B: Latency reduction for MAC CE based PL-RS activation
* Opt 2-C: One-shot timing update for TCI state update

Note: A number of companies argued that most of the schemes in this category can be handled exclusively in RAN4 | **Opt 2-A**: ZTE (independent pools for a time period), vivo, OPPO, Qualcomm, Ericsson, Apple, NTT Docomo, Nokia**Opt 2-B**: ZTE (independent pools for a time period), vivo, Qualcomm**Opt 2-C**: Ericsson**Discuss first in RAN4:** IDC, Samsung**Send LS to RAN4**: MTK, Ericsson |

Overall the following summary on each of the options supported by >1 companies can be inferred (courtesy of Bo/ZTE):

|  |
| --- |
| Option 1-A:1. UE-initiated beam selection based on, e.g. CFRA, CBRA, UL CG, MAC-CE or UCI
	* Cat-1: The selected beam (DL-only or DL/UL) is reported by an event-triggered UE beam report.
		1. Example-1: UE sends a CBRA to gNB and after CBRA, all the channels that a unified TCI is applied for should be based on the SSB/CSI-RS associated with the PRACH.
		2. Example-2: UE initiated beam reporting based on PRACH or UL CG, and DL beam selection
		3. Example-3: MAC CE on PUSCH is sent by UE to inform the appropriate DL/UL beam to gNB, where the MAC-CE may be analogous to BFR MAC-CE.
	* Cat-2: The selected beam is reported by a legacy UE beam report (NW-initialized)
2. UE-initiated beam activation based on beam reporting
	* The reported beam is applied directly if the number of supported activated beam by the UE is one and/or after receiving gNB response signaling.
	* Cat-2: The activated beam is reported by a legacy UE beam report (NW-initialized)
		1. Event-driven mechanism (Cat-1) can be further considered.
3. UE initiated UL-only beam selection
	* If the channel conditions are bad for current beam, the UE can automatically select an alternative beam from the other beams in the gNB-configured set containing more than one UL beam.

Option 1-B: 1. AP TRS measurement can be triggered after beam activation MAC-CE to avoid SSB measurement
	* Note: CSI reporting is not needed.
2. Beam measurement and reporting is directly triggered by beam indication
	* TCI state indicated to the UE is linked (by configuration) to a CSI-RS (or SRS) resources (e.g., a CSI-RS set with repetition = ‘ON’) for measurement and measurement report
	* Note: Above applies to P2/P3/TRS/CSI

Option 1-C:1. On CMR resource configuration for aperiodic beam measurement and reporting, multiple CMR resource sets can be configured
	* Additional UE report to aid at least P3 related measurement/report configuration, such as triggering request, the number of candidate RS(s) or periodicity) should be considered.
2. UL beam sweeping with each set (joint U2+U3, e.g., by SRS) and joint DL and UL beam sweeping (e.g., P2+U3)
3. An indication on whether intra-symbol beam sweeping is possible or not can be provided by gNB

Opt 2-A:1. UE is to store the QCL properties of the root SSB (from MTK, QC, DOCOMO, Samsung and ZTE).
	* Example-1: UE shall store the QCL propertied once its measurement report is sent, e.g., for UE-initiated beam activation/selection as in Opt 1-A.
	* Example-2: UE can maintain an independent pool of QCL properties of the root SSBs by MAC-CE
2. Beam indication signaling can trigger aperiodic CSI-RS for BM and aperiodic TRS to speed up beam refinement and time/frequency offset tracking (from Apple).
3. Beam activation MAC CE can trigger aperiodic TRS to speed up time/frequency offset tracking (from vivo).

Opt 2-B:1. UE is to store the PL estimate from an independent PL-RS pool activated by MAC-CE (from ZTE).
2. UE shall use L1-RSRP as metric for pathloss estimation during the transition period (from Apple).
3. The required sample # should be up to UE capability (from QC).
4. Simultaneous PL-RS update across BWPs/CCs (from DOCOMO and vivo).
 |

The following **observation** can be made:

* Given the amount of time left for Rel-17 and the slow progress rate of 8.1.1 (some caused by the inter-WG ping-pong effect):
	+ Choosing more than one options is clearly unrealistic for Rel-17 time-frame
	+ Group 2 is more prone to the ping-ping effect
* Among all the options, Opt 1-A draws more interest than the other options

Based on the above observation, the following proposal can be made:

**Proposal 6.A**: On Rel-17 enhancements to facilitate advanced beam refinement/tracking, in Rel-17, further focus study (including down-selection) and, if needed, specification effort on Opt 1-A as agreed in RAN1#105-e (UE-initiated beam selection/activation based on beam measurement and/or reporting, without beam indication or activation from NW) comprising:

* UE-initiated (DL-only or DL/UL) beam selection, including the following options
	+ The selected beam is reported by an event-triggered UE beam reporting via, e.g. UCI, MAC CE, PRACH, UL CG, or CBRA/CFRA
	+ The selected beam is reported by a legacy UE beam report (NW-initialized)
* UE-initiated beam activation based on beam reporting
	+ The reported beam is applied directly if the number of supported activated beam by the UE is one and/or after receiving gNB response signaling
* UE-initiated UL-only beam selection
	+ The UE can select an alternative beam from the other beams in the gNB-configured set containing more than one UL beam

Table 10 Additional inputs: issue 6

|  |  |
| --- | --- |
| **Company** | **Input** |
| **From Round 0** |
| Ericsson | Opt 1-C is supported from Rel-15. One DCI can point at one aperiodic trigger state, which points at two report settings. These two report settings point at two different aperiodic CSI-RS resource sets ,and where the slot offset is defined differently for the two aperiodic CSI-RS resource sets. |
| ZTE | Generally, we think that the down-selection should be based on the popularity of each candidates, and whether the companies’ proposal can be converged. If whether to send an LS to RAN4 is controversial, we may focus on group-1 firstly. From ZTE perspective, our first preference is Opt 1-C. For Opt 1-A, we think that gNB response, e.g., UE initialized beam activation by legacy UE reporting and then DCI indication for confirmation, is necessary. For Opt 1-B, we slightly prefer to focus on TRS firstly for narrowing the scope. |
| InterDigital | We share similar views with ZTE, in terms of topic prioritization, that we can focus on Group 1 first.For Opt 1-A, we believe the UE-initiated beam selection/activation (if adopted) should be at least restricted within a certain set of TCI states (not freely chosen by the UE), meaning at least a certain degree of controlling a candidate beam set (e.g., TCI state group) indicated to the UE should be given to the gNB side, for reliability of overall beam management procedures.  |
| Mod  | For the next round we will focus on Group 1 and see if we can progress.  |
| **ROUND 4** |
| Mod V0 | **Please share your inputs on proposal 6.A** |
| Qualcomm | Support with the following changes: 1) Remove “NW initialized”, which seems conflict with the upper level bullet for UE initiated beam selection to our understanding; 2) Put all conditions as examples, and add one more example, which is mentioned in our feedback in the offline email discussion during the summer. * UE-initiated (DL-only or DL/UL) beam selection, including the following options
	+ The selected beam is reported by an event-triggered UE beam reporting via, e.g. UCI, MAC CE, PRACH, UL CG, or CBRA/CFRA
	+ The selected beam is reported by a legacy UE beam report ~~(NW-initialized)~~
* UE-initiated beam activation based on beam reporting
	+ The reported beam is applied directly under certain condition(s), e.g. if the number of supported activated beam by the UE is one and/or after receiving gNB response signaling, or if UE does not receive any beam updating indication within a certain duration after the report, i.e. no beam overwriting command from gNB
* UE-initiated UL-only beam selection
	+ The UE can select an alternative beam from the other beams in the gNB-configured set containing more than one UL beam
 |
| Samsung | We can accept proposal for progress. |
| Apple | We suggest we focus on “UE-initiated (DL-only or DL/UL) beam selection”, it would be challenging to finish all of them, but if we finish UE initialted beam selection, the other two would become unnecessary. |
| ZTE | Our first preference is Option 1-C whose scope is limited with clear benefits.* On CMR resource configuration for aperiodic beam measurement and reporting, multiple CMR resource sets cans be configured
	+ Additional UE report to aid at least P3 related measurement/report configuration, such as triggering request, the number of candidate RS(s) or periodicity) should be considered.

Regarding Moderator’s proposal, we can live with them if having majority support. But to be honest, the scope of the proposal may be a little bit big, and some down-selection seems to be needed this meeting. For instance, we only focus one of three sub-topics with high priority, and if so, we slightly prefer ‘UE-initiated beam activation based on beam reporting ’. |
| InterDigital | Support **Proposal 6.A** for progress with the following added bullet for FFS, as we think at least the NW should be able to control a beam group within which the UE is allowed to do the UE-initiated beam selection. Otherwise, UE may freely choose a beam, which may be out of control from the NW side, not guaranteeing reliability. The NW-indication of the beam group can be via a MAC-CE (not by RRC) improving the latency. Qualcomm’s revision is acceptable to us, so the following is the suggested updates:* UE-initiated (DL-only or DL/UL) beam selection, including the following options
	+ The selected beam is reported by an event-triggered UE beam reporting via, e.g. UCI, MAC CE, PRACH, UL CG, or CBRA/CFRA
	+ The selected beam is reported by a legacy UE beam report ~~(NW-initialized)~~
	+ FFS on NW-indication of a beam group in which the UE is allowed to do the beam selection, e.g., the NW-indication via MAC-CE
* UE-initiated beam activation based on beam reporting
	+ The reported beam is applied directly under certain condition(s), e.g. if the number of supported activated beam by the UE is one and/or after receiving gNB response signaling, or if UE does not receive any beam updating indication within a certain duration after the report, i.e. no beam overwriting command from gNB
* UE-initiated UL-only beam selection
	+ The UE can select an alternative beam from the other beams in the gNB-configured set containing more than one UL beam
 |
| LG | It looks that the desription of the second bullet would have the same meaning as the first bullet. We suggest the following revision:* UE-initiated beam activation based on beam reporting
	+ ~~The reported beam is applied directly if the number of supported activated beam by the UE is one and/or after receiving gNB response signaling~~The reported beam(s) are activated as active TCI/spatial relation RS(s) automatically
 |

# 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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