**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 behaviorsThen, 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: SupportProposal 1.E: SupportProposal 1.F: Do not support to introduce explicit signaling for this purpose.  |
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### Issue 2 (inter-cell beam management)

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.1 | AgreementOn 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 cellsNote: 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, ZTEReporting timing offset in beam report: vivoPRACH for TA measurement: Apple, NTT Docomo, ZTE |
| 2.9 | What “a UE can transmit to or receive from only a single cell” (DPS) entailsNote: This issue was identified in RAN#92 | UE-specific channels: [Huawei/HiSi], Samsung, Futurewei, Ericsson, IntelAll data and control channels: Apple, MTK, ZTE |
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**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: SupportProposal 2.A.2: SupportProposal 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
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### 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 |
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**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

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| **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 symbols2. 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.  |
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### 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 |
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**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

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| **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.  |
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### 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 |
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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.  |
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### Issue 6 (advanced beam refinement/tracking)

(Later rounds)

# References

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| --- | --- | --- | --- |
| 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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