**3GPP TSG RAN WG1 #105-e R1-2105290**

**e-Meeting, May 10th – 27th, 2021**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

**Title:** Moderator summary for multi-beam enhancement

**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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| * Enhancement on multi-beam operation, mainly targeting FR2 while also applicable to FR1:
	+ Identify and specify features to facilitate more efficient (lower latency and overhead) DL/UL beam management to support higher intra- and L1/L2-centric inter-cell mobility 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)
	+ 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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| **#** | **Issue** | **Companies’ views** |
| 1.1 | For QCL-Type D configuration in TCI state(s) shared across a set of CCs (that is associated with the same gNB beam):* **Alt1**: Separate QCL-Type D RS for each of the CCs can be determined from the TCI state(s). The determined QCL-Type D RSs for the set of CCs are further associated with a same QCL-Type D RS.
* **Alt2**: A single QCL-Type D RS for the set of the CCs is determined from the TCI state(s), and support enhanced QCL chain:
	+ **Alt.2-1**: Support Opt. A only.
	+ **Alt.2-2**: Support Opt. B only.
	+ **Alt.2-3**: Support both Opt. A and Opt. B.

Options of the enhanced QCL chain:* Opt. A: The QCL-Type A TRS and, if any, QCL-Type D CSI-RS, with different CSI-RS resources.
* Opt. B: The QCL-Type A TRS and, if any, QCL-Type D SSB.
 | **Alt 1**: Nokia/NSB, CATT, Apple, Sony, NTT Docomo, Intel**Alt 2-1**: OPPO, MTK (2nd)**Alt 2-2**:**Alt 2-3**: vivo, Samsung, ZTE, Qualcomm, MTK (1st)  |
| 1.2 | Setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index): * AltA. The setting of (P0, alpha, closed loop index) is also associated with UL or (if applicable) joint TCI state
* AltB. The setting of (P0, alpha, closed loop index) is also included with UL or (if applicable) joint TCI state
* AltC. The setting of (P0, alpha, closed loop index) is neither associated with nor included in UL or (if applicable) joint TCI state

Note: It has been agreed that the setting of (P0, alpha, closed loop index) is associated with UL channel or UL RS (therefore the setting is channel- and signal-specific). | **AltA**: Lenovo/MoM, Spreadtrum, CMCC (PUSCH/PUCCH), Nokia/NSB, Futurewei, Fraunhofer IIS/HHI, ZTE, CATT (MAC CE update), OPPO (PUSCH, PUCCH), Apple, NTT Docomo, MTK, Intel (2nd preference)**AltB**: Nokia/NSB, Samsung, IDC, Apple, Qualcomm, NTT Docomo (2nd pref), LG, Intel**AltC**: vivo, Ericsson (P0 and alpha), Huawei/HiSi, OPPO (SRS, per resource set), Sony  |
| 1.3 | Path-loss measurement (PL RS):* AltA. PL-RS can be included in UL TCI state (or, if applicable, joint TCI state).
* AltB. PL-RS can be associated with (but not included in) UL TCI state (or, if applicable, joint TCI state)
	+ FFS: Exact association mechanism
* AltC. UE calculates path-loss based on periodic DL RS configured as the source RS for determining spatial TX filter in UL or (if applicable) joint TCI state
	+ FFS: If a PL RS is not included in or associated with the UL TCI state (or, if applicable, joint TCI state), whether the UE can estimate path-loss based on the PL-RS of an UL RS provided in an UL TCI state (or, if applicable, joint TCI state) as a source RS for determining the spatial TX filter.
 | **AltA**: Nokia/NSB, Ericsson, IDC, Fraunhofer IIS/HHI, Samsung (2nd preference), OPPO, Qualcomm, AT&T, NTT Docomo, LG, Intel**AltB**: Lenovo/MoM, Spreadtrum, CMCC, Futurewei, ZTE, CATT (MAC CE update), Huawei/HiSi, Sony, MTK**AltC**: vivo, Nokia/NSB (if not configured in TCI state), Samsung, ZTE (if not configured in TCI state), Apple**One solution only** (no mixture optional/default): NTT Docomo, Ericsson, Samsung, Qualcomm |
| 1.4 | See table below (cf. offline discussion [1])Do the following ‘other signal(s)/channel(s)’ admit Interpretation 1 when operating with Rel-17 unified TCI? | CSI-RS resource for CSI:* **Yes**: Lenovo/MoM, Spreadtrum, Nokia, Ericsson, Samsung, Fraunhofer IIS/HHI, ZTE (only AP), OPPO, Apple (at least AP), Convida, APT
* **No**: vivo, Huawei/HiSi

Some CSI-RS resource(s) for BM (if so, which one(s), e.g. aperiodic, repetition ‘ON’)* **Yes**: Nokia/NSB, Ericsson, Samsung, Fraunhofer IIS/HHI (rep ON), OPPO (one resource with rep ON), Apple (at least AP), APT (rep ON)
* **No**: vivo, Spreadtrum, Huawei/HiSi

CSI-RS for tracking:* **Yes**: Lenovo/MoM, Ericsson
* **No**: vivo, Spreadtrum, Samsung, Huawei/HiSi, MTK

 Some SRS resources or resource sets for BM:* **Yes**: Ericsson, OPPO
* **No**: Huawei/HiSi

Non-UE-dedicated reception on PDSCH and all/subset of CORESETs:* **Yes**: vivo
* **No**: Huawei/HiSi
 |
| 1.5 | See table below (cf. offline discussion [1])For ‘other signal(s)/channel(s)’ which do not admit Interpretation 1 when operating with Rel-17 unified TCI (i.e. only Interpretation 2 is applicable), what TCI state update/configuration mechanism is used? | **Rel-15/16 update/configuration mechanism**: Fraunhofer IIS/HHI, Samsung, OPPO, ZTE, MTK**Rel-17 update/configuration mechanism (using M>1 or N>1)**: vivo |
| 1.6 | For separate TCI, UL TCI state poolAlt1: Shared pool with joint/DL TCI stateAlt2: Separate pool  | **Alt1**: vivo, Spreadtrum, Samsung, Xiaomi, ZTE, Qualcomm, MTK, Convida, NTT Docomo, Intel**Alt2**: CMCC, Ericsson, Futurewei, Huawei/HiSi, Fraunhofer IIS/HHI |
| 1.7 | TCI state pool for CAAlt1: Separate, per CCAlt2: Shared among all CCsNote: This is related to 1.1.  | **Alt1:** Nokia/NSB, Huawei/HiSi, OPPO**Alt2:** vivo, Spreadtrum, Apple, Samsung, Xiaomi, Sony, Qualcomm, NTT Docomo, MTK, Intel  |
| 1.8 | Maximum value of M (DL) and N (UL) along with the use case(s) | Max M:* **1 for sTRP**: Spreadtrum, ZTE, Samsung, Convida, NTT Docomo, MTK
* **>1 only for mTRP**: Samsung (M=2), Apple (M=2), LG
* **>1 for uses other than mTRP (specify)**: Futurewei, CATT, Qualcomm

Max N:* **1 for sTRP**: Spreadtrum, ZTE, Samsung, Convida, NTT Docomo, MTK
* **>1 only for mTRP/panel**: Samsung (N=2), Apple (N=2), LG
* **>1 for uses other than mTRP (specify)**: Futurewei, CATT, Qualcomm
 |
| 1.9 | If M>1 and/or N>1 are supported, whether this implies simultaneous reception with different DL QCL(s) or transmission with different UL spatial filter(s)  | **Yes**: Apple **No**:  |
| 1.10 | Additional source RS type for DL QCL Type-D reference for DL common UE-dedicated reception on PDSCH and all/subset of CORESETsNote: CSI-RS for tracking (TRS) and CSI-RS for BM have been agreedNote: There are currently two interpretations on the agreement regarding CSI-RS for CSI: 1) Agreeing on reusing Rel-15/16 QCL rules implies CSI-RS for CSI is also agreed, 2) Only CSI-RS for tracking and BM were listed in the agreement, so CSI-RS for CSI is not yet agreed | SSB, with TRS as QCL Type-A source RS* **Yes:** vivo, Samsung, ZTE, MTK, NTT Docomo
* **No:** Spreadtrum, OPPO, Apple, Intel

SRS for BM, optionally with TRS as QCL Type-A source RS* **Yes:** vivo, Spreadtrum, Nokia/NSB, Samsung, IDC, ZTE, Convida
* **No:** Ericsson, Fraunhofer IIS/HHI, OPPO

CSI-RS for CSI* **Yes:** CMCC, ZTE, Sony
* **No:** vivo, Spreadtrum, Samsung, OPPO
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**From offline discussion on how Rel-17 unified TCI applies to ‘other signals/channels’ (1-4 and 1-5):**

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| --- |
| For discussion purposes, the term ‘other signal(s)/channel(s)’ refers to channel(s), CORESET(s), or a signal(s) *other than* (DL) UE-dedicated reception on PDSCH and all/subset of CORESETs), as well as (UL) dynamic-grant/configured-grant based PUSCH and all of dedicated PUCCH resources. That is:* For DL: CSI-RS resource for CSI, some CSI-RS resource(s) for BM, CSI-RS for tracking, non-UE-dedicated reception on PDSCH and all/subset of CORESETs
* For UL: Some SRS resources or resource sets for BM

Two possible interpretations on how Rel-17 unified TCI applies to ‘other signal(s)/channel(s)’. We use CSI-RS resource for CSI as an example to illustrate the point. * Interpretation 1: The CSI-RS resource for CSI shares the same (Rel-17 DL or, if applicable, joint) TCI state machine (hence ‘DL RX beam tracking loop’) as that for UE-dedicated reception on PDSCH and all/subset of CORESETs. This works regardless of the values of M and/or N.
	+ In this case, the Rel-17 DL or, if applicable, joint TCI state used for the CSI-RS resource for CSI needs to be associated with some UE-dedicated reception on PDSCH and all/subset of CORESETs.
* Interpretation 2: The CSI-RS resource for CSI uses a different (Rel-17 DL or, if applicable, joint) TCI state machine (hence ‘DL RX beam tracking loop’) as that for UE-dedicated reception on PDSCH and all/subset of CORESETs. This [may] require M>1 and/or N>1 [if Rel-17 TCI state update/configuration mechanism is used].
	+ In this case, a separate Rel-17 DL or, if applicable, joint TCI state dedicated to the CSI-RS resource for CSI can be used without any association with any UE-dedicated reception on PDSCH and all/subset of CORESETs.
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The following observation can be made:

* (1.2, 1.3) These two issues have bene discussed since RAN1#103-e (11/2021) and need to be concluded. Preferences from companies do not change significantly although they are better understood. In general, a number of companies prefer not to support two-scheme (default/optional) solutions as those would impose complication on both NW and UE implementation.
	+ On PL-RS, detailed aspects of the PL-RS can be further discussed after proposal 1.2 is agreed.
* (1.1/1.7) From offline discussion [1], proposals 1.3 (on CA QCL) is a good compromise between Alt1 and Alt2 proponents (Alt1 represents slight majority view).
* (1.4, 1.5) From offline discussion [1], proposals 1.4 (on applicability and use of Rel-17 TCI states) may be agreed after some discussion. Proposal 1.5 and 1.6 are good starting points for finalizing the issue in this meeting.
* (1.10) The situation has not changed since RAN1#103-e. It is time to conclude.

Based on the above observation, the following moderator proposals can be made:

**Proposal 1.1**: On the setting of UL PC parameters except for PL-RS (P0, alpha, closed loop index) for Rel.17 unified TCI framework, the setting is either included in or associated with UL TCI state or (if applicable) joint TCI state.

* Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed) is up to RAN2

**Proposal 1.2**: On path-loss measurement for Rel.17 unified TCI framework, a PL-RS (configured for path-loss calculation) is either included in or associated with UL TCI state or (if applicable) joint TCI state.

* If theDL RS in the UL or (if applicable) joint TCI state to provide spatial relation indication is different from PL-RS, path-loss measurement is up to UE implementation
* Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed) is up to RAN2
* FFS: detailed aspects of PL-RS, e.g. CSI-RS type(s), time-domain behavior(s), restriction on configuration

**Proposal 1.3**: On Rel.17 unified TCI framework, [a single RRC pool of TCI states is used] for common TCI state ID update and activation to provide common QCL information and/or common UL TX spatial filter(s) across a set of configured CCs/BWPs

* A CC~~-~~specific source RS can be determined from the indicated common TCI state ID to provide QCL Type-D indication and to determine UL TX spatial filter. The determined CC-specific source RSs for the set of configured CCs/BWPs are further associated with a same QCL-TypeD RS.
	+ Note: From a previous agreement, the common TCI state ID implies that the same/single RS determined according to the TCI state(s) indicated by a common TCI state ID is used to provide QCL Type-D indication and to determine UL TX spatial filter across the set of configured CCs/BWPs
	+ [FFS: how to provide the CC/BWP-specific RSs in a TCI state of the single RRC TCI state pool shared among the set of configured CCs/BWPs, e.g., the BWP/CC ID for the source RS for QCL Type-D reference and/or UL TX spatial reference can be absent in a TCI state]
* “A set of configured CCs/BWPs” includes all the BWPs in the set of configured CCs in one band

**Proposal 1.4**: On Rel.17 unified TCI framework,

* Any DL RS or DL physical channel that is a valid target signal/channel within the Rel-15/16 QCL rules can be configured as a target signal/channel of a Rel-17 DL TCI (hence the Rel-17 DL TCI state pool)
* Any UL RS or UL physical channel that is a valid target signal/channel within the Rel-15/16 UL spatial relation rules can be configured as a target signal/channel of a Rel-17 UL TCI (hence the Rel-17 UL TCI state pool)

**Proposal 1.5**: On Rel.17 unified TCI framework, in RAN1#105-e, discuss and decide

* Whether each of the following DL RSs and channels can share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC
	+ CSI-RS resources for CSI
	+ Some CSI-RS resources for BM, if so, which ones (e.g. aperiodic, repetition ‘ON’)
	+ CSI-RS for tracking
	+ Non-UE-dedicated reception on PDSCH and all/subset of CORESETs
* Whether each of the following UL RSs and channels can share the same Rel-17 TCI state as dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC
	+ Some SRS resources or resource sets for BM

**Proposal 1.6**: On Rel.17 unified TCI framework, for the following (‘other’) signal/physical channel:

* Any DL RS or DL physical channel that does not share the same Rel-17 TCI state as UE-dedicated reception on PDSCH and for UE-dedicated reception on all or subset of CORESETs in a CC
* Any UL RS or UL physical channel that does not share the same Rel-17 TCI state dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC,

Discuss and down-select in RAN1#105-e between the following two alternatives:

* Alt1. Rel-15/16 TCI state and, if applicable, UL spatial relation update signaling/configuration mechanism(s) are reused to update/configure the Rel-17 TCI state
* Alt2. New TCI state update signaling/configuration mechanism(s) are used, e.g. using M>1 and/or N>1 with Rel-17 MAC-CE/DCI-based beam indication for Rel-17 joint/separate TCI

**Conclusion 1.7**: On Rel.17 unified TCI framework, in RAN1#105-e, there is no consensus on supporting the following source RS types for DL QCL Type-D reference for DL common UE-dedicated reception on PDSCH and all/subset of CORESETs:

* SSB
* SRS for BM
* CSI-RS for CSI

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** |
| MediaTek | P1.1 and P1.2: Support. We would like to further check whether the signaling (RRC or MAC-CE) to provide the association is also decided by RAN2 if ‘associated with’ is adopted by RAN2. If so, we prefer to further clarify it in the proposal. For example, * Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed and the signaling) is up to RAN2

P1.3: We can support the proposal if the brackets of [a single RRC pool of TCI states is used] are removed. Regarding how to provide the “CC-specific” RSs in a TCI state for multiple CCs, the BWP/CC ID for the source RS can be absent in a TCI state, and RS will be located in the active BWP in each CC by default.P1.4: We prefer not to introduce any new signaling mechanism for “other” signals/channels not applying Rel-17 TCI state machine. However, it may not be possible to reuse Rel-15/16 UL spatial relation update signaling/configuration mechanism(s) to update/configure the Rel-17 TCI state for “other” UL signals/channels not applying Rel-17 TCI state machine. Since RS index is directly provided as spatial relation, it is quite different from TCI state. Thus, for UL part in P1.4, we prefer to leave it for further study.P1.5: SupportP1.6: For Alt1, as mentioned above, we see it may not be possible to reuse Rel-15/16 UL spatial relation update signaling/configuration mechanism(s) to update/configure the Rel-17 TCI state for “other” UL signals/channels not applying Rel-17 TCI state machine.P1.7: Support |
|  Nokia/NSB | Proposal 1.1Open for further discussionProposal 1.2 Not support subbullets. We don’t think PL measurement can depend on UE implementation. It should be clarified in the spec. We can only accept the main bullet only. And for the clarification, in our understanding, when we say association to TCI state, we may consider association to the TCI index not to the TCI state itself. Can we confirm the general understanding? **Proposal 1.2**: On path-loss measurement for Rel.17 unified TCI framework, a PL-RS (configured for path-loss calculation) is either included in TCI state or associated with index/codepoint of UL TCI state or (if applicable) joint TCI state.* ~~If the DL RS in the UL or (if applicable) joint TCI state to provide spatial relation indication is different from PL-RS, path-loss measurement is up to UE implementation~~
* ~~Whether it is ‘included in’ or ‘associated with’ (including the manner it is performed) is up to RAN2~~
* ~~FFS: detailed aspects of PL-RS, e.g. CSI-RS type(s), time-domain behavior(s), restriction on configuration~~

Proposal 1.3: We slightly prefer separated TCI pool per CC, but can be open for further discussion.Proposal 1.4: SupportProposal 1.5: SupportProposal 1.6: Support |
| Intel | Proposal 1.1: OK. Also OK with Mediatek’s clarificationProposal 1.2: OK with the main bullet and 2nd sub-bullet. Share Nokia’s concern on UE implementation based PL measurement. Would be good have further discussion on this case. We can keep it as FFS for now.Proposal 1.3: OK in principle. Proposal 1.4 – 1.6: Our general preference is to implement a clean design of Rel-17 unified TCI framework which replaces the spatial relation information signaling from Rel-15/16. To this end, leaving some configurations to re-use old framework while some use the new framework is not preferable. The two frameworks should not co-exist down the road making the whole design more complicated. As a result, in Proposal 1.6, we are not sure how Alt.1 works, especially since the Rel-17 UL TCI state definition and contents are not finalized yet.  |
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### Issue 2 (L1/L2-centric inter-cell mobility)

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
| 2.1 | Support CSI-RS associated with/configured for non-serving cell(s) as a measurement RSNote: Supporting this implies the support of Rel-15 CSI-RSRP as beam metric/reporting | CSI-RS for mobility/RRM associated with NSC:* **Yes**: Lenovo/MoM, Huawei/HiSi, Sony, LG
* **No**: Nokia/NSB, Samsung, OPPO, MTK

CSI-RS for BM configured for NSC:* **Yes**: Nokia/NSB, Ericsson, AT&T
* **No**: Samsung, OPPO, MTK

CSI-RS for tracking (TRS) configured for NSC:* **Yes**: --
* **No**: Samsung, OPPO, MTK
 |
| 2.2 | Maximum value of K (beams associated at least with non-serving cell(s) reported in a single CSI reporting instance), i.e. KMAXNote: UE capability of supporting < KMAX is neither ruled out nor within the scope of 2.2 | **4**: vivo, Spreadtrum, MTK (if cell = 1)**8**: Nokia/NSB, Ericsson, AT&T, CATT (at least), MTK (if cells > 1) **16**: Huawei/HiSi, Samsung  |
| 2.3 | 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**: OPPO, MTK, CATT, Intel**Alt2**: Samsung   |
| 2.4 | The maximum value of NMAX (number of non-serving cell(s) RRC configured for measurement/reporting) Note: UE capability of supporting <Nmax is neither ruled out nor within the scope of 2.4 | **1**: Spreadtrum, OPPO**>1 (specify)**: Ericsson (FFS the maximum value), CATT, Samsung (4), Xiaomi (3)  |
| 2.5 | Whether to support the following reporting behavior | Periodic**:*** **Yes**: Nokia/NSB, MTK, Samsung (with restriction), Spreadtrum
* **No**:

Semi-persistent**:*** **Yes**: Nokia/NSB, MTK, Samsung, ZTE, Spreadtrum
* **No**:

Aperiodic**:*** **Yes**: Nokia/NSB, MTK, Samsung, ZTE, Spreadtrum
* **No**:

Event-driven**:*** **Yes (specify event)**: Nokia/NSB, Xiaomi (L3 Events A2~A6 or Event B1 or new L1 event), ZTE (event triggered by L3 mobility measurement), Apple (L1-RSRP of NSC is beyond L1-RSRP of SC plus an offset), AT&T, Sony (L1 metric of NSC is beyond L1 metric of SC plus an offset), Qualcomm, Samsung
* **No**: MTK
 |
| 2.6 | Supported DL QCL Type-D and/or UL TX spatial reference source RS type(s) for L1/L2-centric inter-cell mobility by extending Rel-17 unified TCI framework to inter-cell indication  | DL QCL Type-D: * *SSB associated with NSC as direct QCL source:*
	+ **Yes**: Nokia/NSB, Samsung, MTK, NTT Docomo
	+ **No**:
* *SSB associated with NSC as indirect QCL source (therefore any CSI-RS resource using NSC SSB can be used as a source RS):*
	+ **Yes**: CMCC, Nokia/NSB, Samsung, Sony, Ericsson, MTK, NTT Docomo
	+ **No**:
* *CSI-RS for RRM:*
	+ **Yes:** Sony, LG
	+ **No:** Samsung, MTK

UL TX spatial reference:* *SSB associated with NSC as direct QCL source:*
	+ **Yes**: CMCC, Samsung, Sony, Ericsson, MTK
	+ **No**:
* *SSB associated with NSC as indirect QCL source (therefore any CSI-RS resource using NSC SSB can be used as a source RS):*
	+ **Yes**: CMCC, Samsung, Sony, Ericsson , MTK
	+ **No**:
* *CSI-RS for RRM:*
	+ **Yes**: Sony, LG
	+ **No**: Samsung, MTK
 |
| 2.7 | Whether to support the following Rel-17 unified TCI types for L1/L2-centric inter-cell mobility | Joint TCI:* **Yes**: Samsung, vivo, Nokia/NSB, MTK
* **No**:

Separate DL/UL TCI (including DL-only, UL-only, and [DL+UL]):* **Yes**: vivo, Nokia/NSB, MTK
* **No**: Samsung (FFS)
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The following observation can be made:

* (2.6, 2.7) For beam indication, at the minimum, indirect QCL with SSB from NSC seems agreeable as a method for spatial reference. In addition, joint TCI can be agreed.
* (2.1) This issue has been discussed for several meetings and there is no consensus (the situation hasn’t changed)
* (2.2) Kmax=8 represents the majority view
* (2.5) No objection to support P/SP/AP, and the majority supports L1-based event-driven reporting

Based on the above observation, the following moderator proposals can be made:

**Proposal 2.1**: On Rel.17 beam indication enhancements for L1/L2-centric inter-cell mobility, support the following:

* Rel-17 DCI-based beam indication (using DCI formats 1\_1/1\_2 with and without DL assignment, including the associated MAC-CE-based TCI state activation) with the TCI field used to update joint TCI state
	+ FFS (to be decided in RAN1#106-e): The use of the TCI field to update separate DL/UL TCI states
* The DL QCL and UL spatial relation rules already agreed for intra-cell scenario, also allowing the use of SSB associated with a physical cell ID different from that of the serving cell as an indirect QCL source
	+ 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 source (source RS)

**Conclusion 2.2**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP, there is no consensus on supporting the following measurement RS types in RAN1#105-e:

* CSI-RS for mobility/RRM associated with non-serving cell
* CSI-RS for BM configured for non-serving cell
* CSI-RS for tracking configured for non-serving cell

**Proposal 2.3**: On Rel.17 multi-beam measurement/reporting enhancements for L1/L2-centric inter-cell mobility and inter-cell mTRP,

* Support at least K=4 and 8, 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
	+ FFS: The support of K=16
* Support NW-controlled periodic, semi-persistent, and aperiodic reporting
	+ FFS: Restriction for periodic reporting, e.g. smaller value(s) of K, number of non-serving cells
* Support L1-based event-driven reporting
	+ FFS: Definition of L1-based event

Table 4 Additional inputs: issue 2

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 3** **2) Share your inputs on the above FL proposals** |
| MediaTek | P2.1: SupportP2.2: SupportP2.3: Support in principle. Regarding K=8, we prefer to support it only when a reporting is associated with more than cells (NSCs and/or SC). Otherwise, we don't see the need to support more than four if a reporting is associated with only one NSC.  |
| Intel | Proposal 2.1: Not ok with the first sub-bullet. MAC-CE activation and TCI state mapping to codepoints for intra-cell is not finalized. For example, if dynamic indication is agreed where both joint and separate DL/UL TCI can be mapped to codepoints, only joint TCI state update is an added constraint and it is not clear why we should agree to this at this point. We can put the entire MAC-CE based codepoint activation part in the FFS. * Rel-17 DCI-based beam indication (using DCI formats 1\_1/1\_2 with and without DL assignment~~, including the associated MAC-CE-based TCI state activation) with the TCI field used to update joint TCI state~~
	+ FFS (to be decided in RAN1#106-e): MAC-CE-based TCI state activation and the use of the TCI field to update joint or separate DL/UL TCI states
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### Issue 3 (beam indication signaling medium)

Table 5 Summary: issue 3

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| **#** | **Issue** | **Companies’ views** |
| 3.1 | Whether both DL TCI and UL TCI states can be signaled in one instance of beam indication DCI formats 1\_1/1\_2 (with and without DL assignment) | **Yes (one TCI field codepoint represents both DL and UL TCI states)**: Nokia/NSB, Ericsson, Samsung, Xiaomi, OPPO, Fujitsu, Intel**No**:  |
| 3.2 | Beam application time (BAT): * Alt1: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the DCI with the joint or separate DL/UL beam indication
* Alt2A: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the acknowledgment of the joint or separate DL/UL beam indication
* Alt 2B: the first slot that is at least X ms or Y symbols after the [first/last] symbol of the acknowledgment of the joint or separate DL/UL beam indication, except that the (new) TCI state update can be applied to the PDSCH, if it exists, (scheduled by the beam indication DCI) and corresponding ACK transmission (provided that the time offset between the DCI and the scheduled PDSCH exceed the threshold, analogous to Rel.15/16)
* Alt2C: Support both Alt1 and Alt2A, and introduce a UE capability that indicates the support of Alt1 or Alt2A
* Alt3: the first slot that is at least X1 ms or Y1 symbols after the [first/last] symbol of the DCI with beam indication and X2 ms or Y2 symbols after the [first/last] symbol of the acknowledgment of the beam indication
 | **Alt1**: vivo, Ericsson, Xiaomi, Convida**Alt2A**: Lenovo/MoM, CMCC, Fujitsu, Samsung (2nd preference), IDC, Spreadtrum, ZTE, CATT, Huawei/HiSi, Apple, Sony, Qualcomm, NEC, NTT Docomo (2nd preference), APT, MTK , Intel**Alt2B**: Nokia/NSB, Samsung (1st preference), Xiaomi, NTT Docomo (1st preference), LG**Alt2C:****Alt3**: OPPO |
| 3.3 | For a UE configured with (supporting/capable of) both joint TCI and separate DL/UL TCI (including DL-only TCI, UL-only TCI, [or DL+UL TCI]), how to signal the switching between joint TCI and separate DL/UL TCI: * AltA. Either joint TCI, DL-only TCI, UL-only TCI, [or DL+UL TCI] can be dynamically indicated via beam indication DCI (i.e. the 8 available TCI codepoints are partitioned for all the TCI “types”)
* AltB. Either joint DL/UL TCI or separate DL/UL TCI can be activated via MAC CE signaling (included in the TCI state activation)
	+ When separate DL/UL TCI is activated, either DL-only TCI, UL-only TCI, [or DL+UL TCI] can be indicated via beam indication DCI

Note: The UE capability/optionality/FG issue is beyond the scope of 3.2 | **AltA**: Lenovo/MoM, Nokia/NSB, ZTE, OPPO, Sony, Convida, APT , Intel (TCI state usage indication via MAC-CE and dynamic switching using DCI)**AltB**: Spreadtrum, CATT, Ericsson, Huawei/HiSi, Samsung, Xiaomi, Apple, Qualcomm, MTK, NTT Docomo  |
| 3.4 | Additional support for DCI ACK/NAK for DCI formats 1\_1/1\_2 with DL assignment when used for beam indication  | **Yes:** Lenovo/MoM (dedicated ACK/NACK bit in codebook), Xiaomi (separate HARQ-ACK bit), Samsung, CATT (only ACK), OPPO (only ACK), Apple, NEC (only ACK)**No:** |
| 3.5 | Support for additional DCI formats for Rel-17 unified TCI framework beam indication (TCI state update) beyond the agreed DCI formats 1\_1/1\_2 with + without DL assignment | **No additional DCI format is supported for beam indication:** Convida**DCI formats 0\_1/0\_2 with UL grant (for UL-only TCI of separate DL/UL TCI)**: IDC, Sony, NEC, MTK, LG, Intel |
| 3.6 | When more than one TCI codepoints are activated by MAC CE, the activated TCI state(s) for the lowest codepoint is/are applied. | **Yes:** Huawei, HiSilicon**No:** Intel |
| 3.7 | When UE is configured with two HARQ priorities, the HARQ ACK/NACK feedback for beam indication DCI is always mapped to high priority codebook with PUCCH resource associated to priority index 1 | **Yes:** Intel**No:**  |

The following observation can be made:

* (3.1) Majority support for signaling both DL and UL TCI in one beam indication instance for separate TCI
* (3.2) Alt2A seems to be the alternative acceptable to (almost) all companies
* (3.3) AltB (MAC-CE-activation based) represents the majority viee and the middle ground between RRC-based (too slow) and codepoint-based (over-partitioning the max 8 available codepoints into joint and separate TCIs – 4 “types” of TCI) switching between joint and separate TCI. It also accommodates (partially) the view of those preferring fully dynamic switching (since the switching among DL, UL, and DL+UL is done via TCI field codepoints)

Based on the above observation, the following moderator proposals can be made:

**Proposal 3.1**: On Rel-17 unified TCI, for separate DL/UL TCI, both DL-only TCI and UL-only TCI states can be updated in one instance of beam indication using DCI formats 1\_1/1\_2 (with and without DL assignment)

**Proposal 3.2**: 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.

**Proposal 3.3**: On Rel-17 unified TCI, for a UE configured with both joint TCI and separate DL/UL TCI (including DL-only TCI, UL-only TCI, or DL+UL TCI), either only joint DL/UL TCI states or only separate DL/UL TCI states can be activated via MAC-CE-based TCI state activation

* When joint TCI states are activated, only joint TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication
* When separate DL/UL TCI states are activated, either DL-only TCI state, UL-only TCI state, or DL+UL TCI state can be updated via the TCI field in DCI formats 1\_1/1\_2 used for beam indication

Table 6 Additional inputs: issue 3

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 5****2) Share your inputs on the above FL proposals** |
| MediaTek | P3.1: SupportP3.2: SupportP3.3: Support. Regarding how to activate joint TCI or separate TCI via MAC-CE-based TCI state activation can be left to RAN2 design. * *How to activate either only joint DL/UL TCI states or only separate DL/UL TCI states is up to RAN2*
 |
| Nokia/NSB | Proposal 3.1: SupportProposal 3.2: SupportProposal 3.3: We prefer no ‘mode like’ separation between indication of joint/separated TCI, since it can be up to gNB which TCI to be associated to each of TCI index. But as our 2nd preference, we can be open for MAC CE based switching. We do not support any slower changes, e.g., RRC. |
| Intel | Proposal 3.1: SupportProposal 3.2: SupportProposal 3.3: Do not support this proposal. We don’t see the need to limit the configurable codepoints to one type of TCI states. As we outlined in our paper, MAC-CE configuring the TCI codepoints can also configure the usage i.e., what type of TCI state the codepoint maps to. In this case, the DCI indication can choose any of the 8 codepoints and they can map to either joint or separate TCI states. Requiring MAC-CE to reconfigure codepoints if gNB needs to indicate separate TCI states is not desirable. We also added Issue 3.7 to the Table 5. In our understanding, the ACK/NACK for beam indication is a very important UCI which is needed to ensure UE and gNB are aligned on which beam is used. In this case, this ACK/NACK feedback should not be dropped in favor of other UCI i.e., prioritization is needed. For the case when a UE is configured with two HARQ codebook priority indices, the beam indication ACK/NACK should always be mapped to the high priority HARQ/ACK codebook.  |
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### Issue 4 (MP-UE)

Table 7 Summary: issue 4

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| **#** | **Issue** | **Companies’ views** |
| 4.1 | Whether to support the following measurement/reporting scheme for UE-initiated panel activation/selection:* Opt1-1: A panel entity corresponds to a reported CSI-RS and/or SSB resource index in a beam reporting instance
	+ 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)
* Opt1-2: A panel entity is referring to a new panel ID within CSI/beam reports
	+ FFS: Detailed design of the new panel ID including the information conveyed by the new panel ID
	+ Note: The association between the new panel ID and the panel entity is determined by the UE
* Opt1-3: No additional specification support
 | **Opt1-1:** Huawei/HiSi, Apple (if capable), Sony (2nd pref), MTK**Opt1-2:** IDC, vivo, Lenovo/MoM, Spreadtrum, CMCC, Samsung (resource set ID), ZTE (global ID), Huawei/HiSi, Sony, Fraunhofer IIS/HHI, Xiaomi, AT&T, NTT Docomo, LGE **Opt1-3:** CATT, OPPO, Ericsson, Apple, APT, Intel |
| 4.2 | Whether to support CB-based SRS resources with different numbers of ports | **Yes**: ZTE, Samsung, CATT, OPPO, Qualcomm, NTT Docomo, LGE, MTK **No**: vivo, APT , Intel |
| 4.3 | Whether to support NCB-based SRS resource sets with different numbers of resources | **Yes**: ZTE, Samsung**No**: |
| 4.4 | Support of NW-initiated panel activation/selection | **Yes**: IDC (TCI state group indication + gNB confirmation), vivo (TCI state update), Huawei/HiSi (handshake), Qualcomm (handshake), Fraunhofer IIS/HHI**No**: Spreadtrum, Sony, Xiaomi  |
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The following observation can be made:

* (4.1) Opt1-2 represents the super-majority view
* (4.2) The additional support for having different # ports for SRS resources represents the majority view

Based on the above observation, the following moderator proposals can be made:

**Proposal 4.1**: On Rel.17 enhancements to facilitate UE-initiated panel activation and selection, a panel entity is referring to a new panel ID within CSI/beam reports

* FFS: Detailed design of the new panel ID including the information conveyed by the new panel ID
* Note: The association between the new panel ID and the panel entity is determined by the UE

**Proposal 4.2**: Support configuring a UE with SRS resources having different numbers of ports for codebook-based UL transmission

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** |
| MediaTek | P4.1: We have concern on Opt1-2. For Opt1-2, if a new panel ID is associated with a beam reporting, which means UE can only initiate one UE panel for that beam reporting. If NW would like to check the link qualities from multiple UE panels, multiple beam reports with different IDs have to be configured. We fail to see why separate reports are needed for each UE panel. Furthermore, if multiple CSI/beam reports with different IDs are configured to UE, UE is required to initiate multiple UE panels, which is not aligned with the spirit of “UE-initiated” panel activation and election. In our opinion, for Opt1-1, only one beam report is needed since SSBRSs/CRIs can correspond to one or multiple UE panels, and UE can decide to activate how many UE panels.P4.2: Support |
| Nokia/NSB | Proposal 4.2: Support. Can we clarify that SRS resources within the same resource set can have different number of ports?**Proposal 4.2**: Support configuring a UE with SRS resources having different numbers of ports within the same resource set for codebook-based UL transmission |
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### Issue 5 (MPE mitigation)

Table 9 Summary: issue 5

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| **#** | **Issue** | **Companies’ views** |
| 5.1 | Whether to support:* Opt 1A. {Rel.16 P-MPR based (beam/panel-level)} + Virtual PHR or a modified version
	+ The modified version may be associated with each activated UL TCI or, if applicable, joint TCI, or associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) from candidate pool, if reported.
	+ The reporting reuses the event-driven mechanisms from the Rel-16 P-MPR reporting
* Opt 1D. {Rel.16 P-MPR based (beam/panel-level)}
	+ The reporting reuses the event-driven mechanisms from the Rel-16 P-MPR reporting
* Opt 2A. {SSBRI(s)/CRI(s) and/or panel indication} + L1-RSRP [L1-SINR] or a modified version that accounts for MPE effect associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured)
	+ FFS: Whether the reporting is UE-initiated (event-driven) and/or NW-initiated
	+ FFS: If Opt2A is selected and there is no consensus on a modified L1-RSRP definition, at least the Rel-15 L1-RSRP definition is reused and virtual PHR may be added
 | **Option 1A**: ZTE, Lenovo/MoM, Apple, OPPO (via MAC CE), Qualcomm, Nokia/NSB, MTK, Convida, NTT Docomo **Option 1D**: vivo (add panel ID in PHR MAC CE), Spreadtrum, Huawei/HiSi, Sony, Xiaomi **Option 2A**: CATT, Apple, Sony, Lenovo/MoM, CMCC, Samsung, Qualcomm, Nokia/NSB, MTK, NTT Docomo, LGE, Ericsson |
| 5.2 | If Opt1A/D in 5.1 is supported:* Alt1. Beam-level reporting
* Alt2. Panel-level reporting
 | **Alt1**: Qualcomm, Nokia/NSB, Convida, MTK, Intel **Alt2**: vivo, Spreadtrum, Huawei/HiSi, Xiaomi, Sony, NTT Docomo  |
| 5.3 | If Opt2A in 5.1 is supported:* Alt1 (beam-level): Reporting of at least SSBRI(s)/CRI(s) to indicate gNB beam(s) that is feasible for UL transmission
* Alt2 (panel-level): Reporting of at least an indicator associated with a UE ‘panel’ that is feasible for UL transmission
 | **Alt1**: CATT, Nokia/NSB, Intel**Alt2**: Lenovo/MoM, Samsung, LG |
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The following observation can be made:

* (5.1) Opt2A represents the majority view, followed by Opt1A

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

**Proposal 5.1**: On Rel.17 enhancements to facilitate MPE mitigation, support the following schemes:

* Opt1A. {Rel.16 P-MPR based (beam/panel-level)} + Virtual PHR or a modified version
	+ The modified version may be associated with each activated UL TCI or, if applicable, joint TCI, or associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured) from candidate pool, if reported.
	+ The reporting reuses the event-driven mechanisms from the Rel-16 P-MPR reporting
* Opt2A. {SSBRI(s)/CRI(s) and/or panel indication} + L1-RSRP [L1-SINR] or a modified version that accounts for MPE effect associated with each of the reported SSBRI(s)/CRI(s) and/or panel indication (if configured)
	+ FFS: Whether the reporting is UE-initiated (event-driven) and/or NW-initiated
	+ FFS: If Opt2A is selected and there is no consensus on a modified L1-RSRP definition, at least the Rel-15 L1-RSRP definition is reused and virtual PHR may be added

Table 10 Additional inputs: issue 5

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 10** **2) Share your inputs on the above FL proposals** |
| MediaTek | Support in principle. But prefer to support Opt2A as NW-initiated since event-driven mechanism is already supported by Opt1A, and Opt2A can be an enhanced beam reporting format. We don't see the need to introduce two schemes with the same reporting types. |
| Nokia/NSB | Support in principle |
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### Issue 6 (advanced beam refinement/tracking)

Table 11 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 1-1A: Beam measurement/reporting/refinement/selection triggered by beam indication (without CSI request)
* Opt 1-1B: UE-initiated beam selection/activation based on beam measurement and/or reporting (without beam indication or activation from NW)
* Opt 1-2: Semi-static NW-configured beam selection (without beam indication and measurement/reporting)
* Opt 1-3: SSB grouping to reduce beam training
* Opt 1-4: Aperiodic beam measurement/reporting based on multiple resource sets for reducing beam measurement latency
 | **Opt 1-1A**: IDC, Nokia/NSB (refinement), Samsung (refinement, M/R)**Opt 1-1B**: IDC (with beam group indication), Nokia/NSB, Futurewei, Ericsson, OPPO, MTK, LG**Opt 1-2**: NTT Docomo**Opt 1-3**: Apple, Ericsson**Opt 1-4**: Nokia/NSB (BFR), ZTE, Samsung |
| 6.2 | Group 2: Reducing activation delay of TCI states and PL-RSs (including other WGs, e.g. RAN4)* Opt 2-1A: Latency reduction for MAC CE based TCI state activation, or frequency/time/beam tracking
* Opt 2-1B: Latency reduction for MAC CE based PL-RS activation
* Opt 2-1C: Latency reduction for MAC CE based PUCCH resource/resource group activation
* Opt 2-2: Direct SCell TCI state activation
* Opt 2-3: Replacing RRC-based with MAC CE (or DCI) based for DL QCL or UL information update
* Opt 2-4: 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 2-1A**: vivo (A-TRS), Ericsson, ZTE, Apple (AP CSI-RS triggering via MAC CE/DCI), NTT Docomo**Opt 2-1B**: vivo, ZTE **Opt 2-1C**: vivo* Other views: Ericsson (under issue 1)

**Opt 2-2**: Qualcomm * Other views: Ericsson (out of scope, CA AI)

**Opt 2-3**: IDC, Lenovo/MoM (associated CSI-RS for SRS resource for NCB)* Other views: Ericsson (unclear target)

**Opt 2-4**: Ericsson |

The following observation can be made:

* (6.1, 6.2) Opt1-1B and Opt 2-1A represent the majority views for Group 1 and 2, respectively. Note that the agreement says “strive for at most one per group”

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

**Proposal 6.1**: On Rel.17 enhancements to facilitate advanced beam refinement/tracking, focus study and, if needed, specification effort on the following options:

* Group 1: UE-initiated beam selection/activation based on beam measurement and/or reporting (without beam indication or activation from NW)
* Group 2: Latency reduction for MAC CE based TCI state activation, or frequency/time/beam tracking

Table 12 Additional inputs: issue 6

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| **Company** | **Input** |
| Mod V0 | **1) Check and update Table 12** **2) Share your inputs on the above FL proposals** |
| MediaTek | Support the proposal |
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# References

|  |  |  |  |
| --- | --- | --- | --- |
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| 5 | R1-2104343 | Further discussion on multi beam enhancement | vivo |
| 6 | R1-2104404 | Enhancements on Multi-beam Operation | Lenovo, Motorola Mobility |
| 7 | R1-2104411 | Enhancements on Multi-beam Operation | Spreadtrum Communications |
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| 25 | R1-2105683 | Discussion on multi-beam operation | NTT DOCOMO, INC. |
| 26 | R1-2105779 | Enhancements on Multi-beam Operation | LG Electronics |
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| 28 | R1-2105828 | Enhancements on Multi-beam Operation | Ericsson |
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