**3GPP TSG RAN WG1 #103-e R1-2009499**

**e-Meeting, October 26th – November 13th, 2020**

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

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

**Document for:** Discussion and Decision

**Change history – Moderator versions**

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| --- | --- | --- |
| **Version** | **Add companies’ inputs** | **Moderator changes** |
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1. Introduction

Picking up from where the group left off in the 1st moderator summary R1-2008147 and the 1st GTW session, below are the summaries and moderator proposals.

1. Summary of companies’ inputs based on the issue category

The listed issues are structured primarily to facilitate some progress on pending issues identified in the agreements made in RAN1#103-e.

* 1. Issue 1 (unified TCI framework)

Table 1 Summary: issue 1

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| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 1.1 | Additional applicability of the common QCL information | CSI-RS resource for CSI:   * **Yes**: vivo, OPPO, Nokia/NSB, Spreadtrum, Convida, Samsung, Qualcomm, ZTE, NTT Docomo, MediaTek, APT, Intel, CATT, LG, Sony, Sharp, AT&T * **No**: Huawei/HiSi   Some CSI-RS resource(s) for BM:   * **Yes**: OPPO, Samsung, Qualcomm, ZTE, NTT Docomo, Intel, CATT, Sony, APT (with repetition “on”), Nokia/NSB (repetition “ON”) Convida * **No**: Huawei/HiSi, vivo, MediaTek, APT (other than repetition “on”), Lenovo/MoM   CSI-RS for tracking:   * **Yes**: vivo, Nokia/NSB, Spreadtrum, Convida, Qualcomm, ZTE (for AP-TRS only), APT, Intel, CATT, Sony, Sharp * **No**: Huawei/HiSi, MediaTek, OPPO   Periodic CSI-RS:   * **Yes**: Qualcomm (separate update), NTT Docomo (prefer resource switching to enable resource sharing across UEs) * **No**: ZTE, Apple | For common QCL:   * Some CSI-RS resource(s) for BM can be used for RX beam refinement (P3), with repetition “on” * CSI\_RS for tracking: need to clarify if this is intended for all tracking CSI-RS   Blue highlighted aspects show good majority view |
| 1.2 | Additional applicability of the common UL spatial filter to SRS for BM | Some SRS (resource set(s)) for BM:   * **Yes**: OPPO, Samsung, Apple, Qualcomm, Intel (with BC), CATT, ZTE, Sony * **No**: Huawei/HiSi, APT, Spreadtrum, Convida, NTT Docomo, MediaTek, Intel (without BC) | Intended for UL RX beam refinement (U2)  Note: Beam correspondence (BC) is assumed. Can Intel’s preference be understood as when separate UL is configured? |
| 1.3 | Maximum value of M (DL) and N (UL) | **Max=1 for sTRP**: CATT, OPPO, MediaTek, Spreadtrum, Convida, Nokia/NSB, Samsung, Fraunhofer IIS/HHI, Apple (M=1, N=1 for non-MPE and M=1, N=2 for MPE), ZTE, APT, Sony  **Max=2 for mTRP**: Nokia/NSB, Fraunhofer IIS/HHI, Apple (M=2), AT&T, APT, Sony  **Max>1**: Sharp, Futurewei, IDC, vivo (multiple beams per TRP, Max=4), ZTE, Qualcomm, Lenovo/MoM, LG | Some companies favoring Max>1 (including Max=2) suggest to progress on unified TCI design for Max=1 to an extent before considering Max>1: Samsung, Nokia/NSB, Fraunhofer IIS/HHI, ZTE  The discussion can progress as follows: 1) Decide first whether to support mTRP, if so, what’s the max #. 2) Decide max # TCIs per TRP (discussion includes use cases).  It is assumed that M and/or N TCIs will be updated together in one beam indication (also cf. 1.4, 1.5)  Blue highlighted aspects show good majority view |
| 1.4 | TCI state applicability to a subset of CORESETs (in addition to all CORESETs) | **Yes**: LGE, Nokia/NSB, Ericsson, Qualcomm, NTT Docomo, APT, Intel, Sharp  **No**: ZTE | Need discussion to clarify potential use cases other than mTRP. For mTRP, it is obvious that one of the M TCI states applies only to a subset of UE-dedicated CORESETs. |
| 1.5 | TCI state applicability to a subset of PUCCHs (in addition to all PUCCHs) | **Yes**: LGE, Nokia/NSB, Ericsson, Qualcomm, APT  **No**: ZTE |
| 1.6 | Support for common TCI state for intra-band and inter-band CA | **Yes**: Futurewei, vivo, CATT, Samsung, OPPO, LGE, Qualcomm, Ericsson, Sony, NTT Docomo, MediaTek, APT (for intra-band only), Intel, ZTE, Nokia/NSB, AT&T  **No**: -- |  |
| 1.7 | Separate UL and DL beam indication (for, e.g. MPE mitigation):  Alt1. Joint TCI including non-corresponding DL QCL and UL spatial filter reference, common pool  Alt2-1. Separate UL TCI, common TCI pool with DL TCI  Alt2-2. Separate UL TCI, separate TCI pool from DL TCI | **Alt1**: OPPO, ZTE, CATT, Convida, Samsung, NTT Docomo, Apple  **Alt2-1**: Xiaomi, Nokia/NSB, Intel, APT, MediaTek  **Alt 2-2**: Futurewei, CMCC, Nokia/NSB, Sony, Fraunhofer IIS/HHI, Xiaomi, APT, Ericsson, AT&T, Qualcomm, MediaTek, Lenovo/MoM | Before concluding this issue, the use case for separate UL beam indication needs to be discussed and understood better. Thus far, the only use case is MPE mitigation (since BC is mandatory).  Blue highlighted aspects show good majority view |
| 1.8 | Additional source RS types for UL TX spatial filter | Non-BM CSI-RS   * **Yes**: Huawei/HiSi, vivo, Nokia/NSB, Ericsson, Qualcomm, ZTE, Sony * **No**: Convida, Apple   Non-BM SRS   * **Yes**: Spreadtrum, Qualcomm, ZTE, Nokia/NSB * **No**: Convida, Apple   DL channels: Fraunhofer IIS/HHI | Note: SSB has been agreed in RAN1#102-e – no need to be discussed again  Blue highlighted aspects show good majority view |
| 1.9 | SRS for BM as source RS for DL RX spatial filter | **Yes**: IDC, vivo, Samsung, Sony, Nokia/NSB, Convida, CATT, Apple (OK with DL RS configured as source RS for SRS for BM, in another word, SRS is a bridge)  **No**: Ericsson, ZTE | Need further discussion if this entails some joint use of SRS with a DL RS to ensure it is functional when UE orientation changes (and whether it will resolve concern)  Blue highlighted aspects show good majority view |
| 1.10 | Additional parameters included in or concurrent with (but not included in) in unified TCI | UL PC parameters (P0/alpha, CL index)   * **Yes**: IDC, Lenovo/MoM, Futurewei, CMCC, Samsung, Qualcomm, ZTE, MediaTek, Intel (for PUCCH), LG, Apple * **No**: Huawei/HiSi   PL RS:   * **Yes**: IDC, vivo, ZTE, OPPO, Lenovo/MoM, Qualcomm, Fraunhofer IIS/HHI, Futurewei, Samsung, MediaTek, Intel, LG, Apple, Sharp * **No**:   UL timing parameters   * **Yes**: LGE (panel-specific) * **No**: Apple, OPPO, MediaTek (should be discussed in MTRP AIs) | At least two factors need to be discussed: 1) common vs separate UL/DL beam indication (cf. NTT Docomo input), 2) whether the parameters are included in the unified TCI or (analogous to Rel.15/16) defined separately from unified TCI (cf. MediaTek input)  It is quite clear that companies see the need for at least the UL PC parameters and PL RS references for the unified TCI framework. But as pointed out by MediaTek, the main question is whether these parameters should be included in the unified TCI framework (as a part of the UL spatial reference) or simply defined concurrently. |
| 1.11 | Support default QCL/spatial relation for joint/common TCI | **Yes**: Huawei/HiSi, vivo (extend R15/R16), Fraunhofer IIS/HHI, NTT Docomo, Ericsson (CORESET with lowest ID), Sharp, Spreadtrum, Qualcomm, Xiaomi, Lenovo/MoM, Intel  **No (not needed)**: Nokia/NSB, MediaTek, OPPO, Apple, Convida, Samsung | Note: If supported, for separate DL and UL beam indication (MPE), whether one default QCL/spatial relation is sufficient (for DL and UL) may need to be discussed  It has been pointed out the that the need is unclear for unified TCI framework. So further discussion seems needed before we can proceed. |
| 1.12 | How to provide QCL information for signals where the common QCL (cf. #1.1, #1.2) is not applicable | **Alt1. Reuse Rel.15/16 TCI/spatial relation:** ZTE, Apple, Sony, Nokia/NSB  **Alt2. NW association with common TCI states:** MediaTek, Samsung | Although this may need to wait until #1.1. and #1.2 progress, listing alternatives for further down selection can help. |

From moderator perspective, concluding on the following matters would facilitate much better discussion not only in this issue (issue 1), but also in other issues in multi-beam enhancements:

* Proposal 1.A has been stable
* Proposal 1.B (issue 1.7): TCI design for separate UL and DL beam indication. Concluding on this would resolve ambiguity in issue 3, 4, and 5
* Proposal 1.C (issue 1.3): maximum value of M (DL) and N (UL): the key questions are (1) whether mTRP should be supported in item 1 design work and if so the maximum # TRPs (DL and UL), (2) maximum # TCIs for a single TRP (analogous to the so-called single-DCI/single-PDCCH approach in Rel.16 mTRP)
  + Better clarity on (2) would lead to better clarity on 1.4 and 1.5
* Proposal 1.D (issue 1.1, 1.2, and 1.12): when the common QCL and common UL spatial filter in joint TCI are applicable (in addition to what have been agreed in RAN1#102-e), and when they are not
* Proposal 1.E (issue 1.8 and 1.9): additional types of source RSs, related to the a/symmetry between DL and UL in terms of QCL and UL spatial reference
* Issue 1.10 needs to be reformulated for further discussion:
  + On UL PC parameters (P0/alpha, CL index), decide among 3 alternatives:
    - Alt1. Include as a part of unified TCI framework (as a part of the UL spatial reference)
    - Alt2. Include concurrently with but outside unified TCI framework
    - Alt3. Not include
  + On PL RS, decide among 2 alternatives
    - Alt1. Include as a part of unified TCI framework (as a part of the UL spatial reference)
    - Alt2. Include concurrently with but outside unified TCI framework

**Proposal 1.A**: On Rel.17 unified TCI framework, support common TCI state update and activation across a set of configured CCs:

* The above applies for intra-band CA
* Working assumption: The above also applies to inter-band CA (pending further confirmation from, e.g. RAN4)

**Proposal 1.B**: On Rel.17 unified TCI framework, to accommodate the case of separate beam indication for UL and DL, support Alt2-2 as described in the RAN1#102-e agreement, that is:

* Utilize two separate TCI states, one for DL and one for UL.
* For the separate DL TCI (note: taken straight from the joint TCI definition agreed in RAN1#102-e):
  + The source reference signal(s) in M TCIs provide common QCL information at least for UE-dedicated reception on PDSCH and all or subset of CORESETs in a CC
* For the separate UL TCI (note: taken straight from the joint TCI definition agreed in RAN1#102-e):
  + The source reference signal(s) in N TCIs provide a reference for determining common UL TX spatial filter(s) at least for dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC,
  + Optionally, this UL TX spatial filter can also apply to all SRS resources in resource set(s) configured for antenna switching/codebook-based/non-codebook-based UL transmissions
* The UL TCI state is taken from another pool of TCI states than the DL TCI state

**Proposal 1.C**: On Rel.17 unified TCI framework, based on theRAN1#102-e agreement the following is supported for both joint DL/UL TCI and separate UL TCI:

* For single-TRP scenarios:
  + The source reference signal(s) in one TCI provide common QCL information at least for UE-dedicated reception on PDSCH and all or subset of CORESETs in a CC (i.e. M=1 in this case)
  + The source reference signal(s) in one TCI provide a reference for determining common UL TX spatial filter at least for dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC (i.e. N=1 in this case)
* Up to 2 TRPs can be supported in DL and/or UL. In case of two TRPs:
  + The source reference signal(s) in up to two TCI states provide common QCL information at least for UE-dedicated reception on PDSCH and all or subset of CORESETs in a CC (i.e. M can be up to 2 in this case)
  + The source reference signal(s) in up to two TCI states provide a reference for determining common UL TX spatial filter(s) at least for dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC (i.e. N can be up to 2 in this case)

**Proposal 1.D**:

* On Rel.17 unified TCI framework, based on theRAN1#102-e agreement the following is supported for both joint DL/UL TCI and separate UL TCI:
  + The source reference signal(s) in M TCIs also provide common QCL information for CSI-RS resource for CSI, [some CSI-RS resource for BM [with repetition ‘ON’], and CSI-RS for tracking]
* For other channels, signals, or CORESETs not included in the Rel/17 unified TCI framework, the QCL information or the UL TX spatial filter is provided from Rel.15/16 TCI or Spatial Relation

**Proposal 1.E**: On Rel.17 unified TCI framework, for both joint DL/UL TCI and separate UL TCI:

* Support the use of non-BM CSI-RS as source RS to determine a UL TX spatial filter
* Support the use SRS for BM as a source RS to represent a DL RX spatial filter, configured together with either a CSI-RS for BM or SSB

Interested companies are encouraged to provide their inputs on the above proposals and reformulated issue 1.10:

Table 2 Additional inputs for round-2 discussion: issue 1 proposals 1.A, 1.B, 1.C, 1.D, 1.E

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| **Company** | **Input** |
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Table 3 Additional inputs: for round-2 discussion issue 1.10 reformulated

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| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 1.10 | Additional parameters included in or concurrent with (but not included in) in unified TCI   * Alt1. Include as a part of unified TCI framework (as a part of the UL spatial reference) * Alt2. Include concurrently with but outside unified TCI framework * Alt3. Not include | UL PC parameters (P0/alpha, CL index)   * **Alt1**: * **Alt2**: * **Alt3**: Huawei/HiSi   PL RS:   * **Alt1**: * **Alt2**: |  |

* 1. Issue 2 (L1/L2-centric inter-cell mobility)

Table 4 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 2.1 | Use cases: network architecture | **NSA with common LTE anchor**: Samsung, Ericsson, Qualcomm, ZTE  **SA**: Samsung, Qualcomm, ZTE | Use cases also need to take into account the limited TU allocation for Rel.17 NR FeMIMO. This implies that enhancements on handover and RRC reconfiguration are practically infeasible unless additional TUs are allocated (RAN level decision). |
| 2.2 | Use cases: CA aspects (in addition to non-CA) | **Include only intra-band CA**: IDC, Samsung, MediaTek, Sony, Sharp  **Include intra- and inter-band CA**: Qualcomm  **Include NR-PSCell**: Ericsson, Qualcomm |
| 2.3 | Use cases: intra- vs inter-frequency, inter-RAT | **Exclude inter-frequency and inter-RAT**: Ericsson, Samsung, ZTE (only for inter-RAT), NTT Docomo  **Include inter-frequency**: ZTE |
| 2.4 | Use cases: sTRP and mTRP | **Only sTRP**: Nokia/NSB, Samsung, OPPO, MediaTek |
| 2.5 | Use cases: DU aspect | **Only cells in the same DU**: Samsung, Qualcomm, ZTE |
| 2.6 | Scope of enhancements:  EG1. Minimum RAN2 impact: TCI and measurement/reporting  EG2. Timing offset issues, TA  EG3. RA/RACH | **EG1 only**: Ericsson, Nokia/NSB, Apple, OPPO, Xiaomi, MediaTek, Lenovo/MoM, ZTE, Sony  **EG1+EG2**: vivo, Qualcomm, Samsung, NTT Docomo  **EG1+EG2+EG3**: Intel, ASUSTeK, CATT, CMCC, Qualcomm, APT | See observation for 2.1-2.5  EG1: whether this also allows beam indication for non-serving-cell PCI(s) needs to be discussed. |
| 2.7 | Method(s) for incorporating non-serving cell info in TCI | **Indicate RS of non-serving cell as QCL source**: IDC, ZTE, Samsung, Nokia/NSB, Lenovo, ASUSTeK, Qualcomm, OPPO, Xiaomi, NTT Docomo, APT, MediaTek, Sharp  **Include PCI in TCI**: vivo, CATT, Sony, Xiaomi, Ericsson, NTT Docomo, APT, ZTE, Nokia/NSB, Sharp | Whether these two are competing alternatives or not may need some discussion.  With TCI enhancement, whether beam indication for non-serving-cell PCI(s) can be done needs to be discussed. |
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From moderator perspective, proposal 2.A was stable. Some clarification, simplification, and terminology alignment with RAN2 are added below:

**Proposal 2.A**: On Rel.17 enhancements to enable L1/L2-centric inter-cell mobility:

* The following use cases are assumed:
  + Network architecture:
    - NSA, i.e. LTE PCell and NR-PSCell
    - SA
  + Intra-band CA
    - FFS: If inter-band CA is also included
  + Intra- RAT (excluding inter-RAT)
  + Intra-frequency scenario:
    - The SSBs of non-serving cells have the same center frequency and SCS as the SSBs of the serving cell
    - An SSB of a non-serving cell is associated with a PCI different from the PCI of the serving cell
  + Support scenarios where all CORESETs are configured without CORESETPoolIndex.
    - FFS: other scenarios
  + Intra-DU operation
* The following enhancement scope is assumed:
  + Working assumption: No RRC reconfiguration signaling is needed when a TCI associated with non-serving cell RS is indicated
    - A non-serving cell RS is an RS that has an SSB of a non-serving cell as direct or indirect QCL source
    - Working assumption: This implies no C-RNTI update during inter-cell mobility
    - To be verified by RAN2
  + Facilitating measurement and reporting of non-serving RSs via incorporating non-serving cell info in TCI and/or Reporting/Resource Settings, along with the necessary measurement and reporting scheme(s)
    - FFS: Detailed/exact method(s)
    - FFS: Whether this also implies the support of beam indication (TCI state update along with the necessary TCI state activation) for TCI(s) associated with non-serving cell RS(s)
  + Facilitate serving cell to provide configurations for non-serving cell SSBs via RRC
    - FFS: details for the configurations, e.g. time/frequency location, transmission power, etc.

Interested companies are encouraged to provide their (additional) inputs, if any, on proposal 2.A.

Table 5 Additional inputs for round-2 discussion: issue 2 proposal 2.A

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* 1. Issue 3 (beam indication signaling medium)

The following agreement was made during the first GTW.

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| **Agreement**  On beam indication signaling medium to support joint or separate DL/UL beam indication in Rel.17 unified TCI framework:   * Support L1-based beam indication using at least UE-specific (unicast) DCI to indicate joint or separate DL/UL beam indication from the active TCI states   + The existing DCI formats 1\_1 and 1\_2 are reused for joint beam indication     - FFS: If additional DCI format(s) are supported, e.g. existing DCI formats 0\_0, 0\_1, 0\_2, 1\_0 as well as new DCI format(s) dedicated for beam indication   + Support a mechanism for UE to acknowledge successful decoding of beam indication     - The ACK/NAK of the PDSCH scheduled by the DCI carrying the beam indication can be used as an ACK also for the DCI     - FFS: Whether any additional specification support is needed   + FFS beam indication for the TCI state assumption/update for the following cases:     - The beam indication UE-specific DCI (i.e. the CORESETs with the DCI received by UE), the scheduled PDSCH by the DCI and the associated PUCCH for the acknowledgment of the beam indication DCI     - Non-UE-specific CORESETs and PUSCH/PDSCH scheduled/activated and PUCCH transmission triggered by non-UE-specific CORESETs * Support activation of one or more TCI states via MAC CE analogous to Rel.15/16:   + At least for the single activated TCI state, the activated TCI state is applied   + The content for the MAC CE is determined based on the outcome of issue 1   + FFS: If supported, default TCI state when more than one TCI states are activated by MAC CE   + Note: There is no implications on the support of single TRP or multi-TRP * Support a UE capability for the minimum beam indication delay   + FFS: Whether to measure beam indication delay from DCI reception or from acknowledgment of DCI   + FFS: The exact supported values e.g. {0.5ms, 2ms, 3ms} * FFS: Additional enhancement such as L1-based beam indication with group-common DCI * FFS: Whether the Rel.17 beam indication can also apply to beam indication for single channel (e.g. PDSCH only, single CORESET) or a subset of channels * FFS: Additional details on extending the support of L1-based beam indication when separate UL (from DL) common beam indication is configured   **Continue email discussion on the yellow part.** |

Interested companies are encouraged to provide their inputs on the following matters:

* Yellow 3.1: “for joint beam indication” text. The only concern raised about this is the applicability for separate UL beam indication. This can be addressed as follows:
  + The existing DCI formats 1\_1 and 1\_2 are reused for joint or separate DL/UL beam indication
    - ...
    - FFS: support for reusing the existing UL-related DCI format(s) for separate UL beam indication
* Yellow 3.2: vivo FFS
  + Please share your view on this FFS points proposed by vivo (needed/not needed, text modification, clarification, etc.)
* Yellow 3.3: UE capability text, revised as follows (per inputs from interested companies, based on where we left off during the GTW discussion):
  + If a fixed beam indication latency is not specified in spec, support a UE capability to accommodate at least two candidate values of beam indication latency
    - FFS: Whether to measure beam indication latency from DCI reception or from acknowledgment of DCI decoding
    - FFS: Depending on the outcome of above FFS, the exact supported candidate values e.g. X ms (examples: 0.5ms, 2ms, 3ms) or Y symbols

Table 6 Additional inputs for round-2 discussion: issue 3 yellow 3.1, 3.2, and 3.3

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* 1. Issue 4 (MP-UE)

Based on the discussion so far, it seems that trying to agree on features (proposal 4.D) would be impossible without agreeing first on use cases and some other more fundamental questions. To narrow down the options, the questions are now asked differently. After this is decided, we should be able to continue our discussion on the FL proposals made in R1-2008147 (where we left off, every point of the FL proposal 4.2 in R1-2008147 was objected).

Interested companies are encouraged to share their views on the issues below (reformulated 4.1, 4.5, and 4.8):

Table 7 Summary for round-2 discussion: issue 4 some fundamental issues

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| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 4.1 | Use cases for fast UL panel selection | **Opt1**: **MPE mitigation**   * Yes: vivo, Samsung, Fraunhofer IIS/HHI, Intel, Nokia/NSB, MediaTek, Qualcomm, Xiaomi, NTT Docomo, APT, IDC, ZTE, LG, Apple, Sony, Sharp * No:   **Opt2: UE power saving**   * Yes: Apple, OPPO, Samsung, Qualcomm, ZTE, LG, Sony * No:   **Opt3: UL mTRP**   * Yes: vivo, APT, Intel, LG * No:   **Opt4: UL interference management**   * Yes: Qualcomm, NTT Docomo, LG, Sony * No:   **Opt5: Support different configurations across panels**   * Yes: Qualcomm, NTT Docomo, Sony, Sharp, Nokia/NSB * No: | Whether **Opt3** should be addressed in MB (item 1) or mTRP (item 2a/c) will need to be discussed.  Use cases would guide the decision on at least #4.6, 4.7, 4.8. For instance, at least Opt1, 2, 4 may suggest that (4.8) there should be an option where the UE decides panel selection/activation. |
| 4.5 | Whether DL RX panel(s) can be different from UL TX panel(s) | **Yes**: LGE, Nokia/NSB (but with overlap), MediaTek, Intel, NTT Docomo (with overlap), Qualcomm, Xiaomi, ZTE, APT (with overlap), Lenovo/MoM, Sony, Samsung  **No**: Huawei/HiSi | Early observation suggests that “Yes, with overlap” could be a good compromise. |
| 4.8 | Which side decides panel selection/activation [Qualcomm, APT, MediaTek] | **Alt1 NW:**  **Yes**: ZTE  **No**:  **Alt2 UE:**  **Yes**: Qualcomm, ZTE, Apple, Sony, MediaTek  **No**: | Note: If NW decides panel activation, UE-to-NW signaling may comprise recommendation whereas NW-to-UE signaling includes assignment |

Table 8 Additional inputs for round-2 discussion: issue 4 (reformulated 4.1, 4.5, and 4.8)

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**Proposal 4.A**: [issue 4.1]

**Proposal 4.B**: [issue 4.5]

**Proposal 4.C**: [issue 4.8]

* 1. Issue 5 (MPE mitigation)

Table 9 Summary: issue 5

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| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 5.1 | When MPE event occurs, is UL spatial filter switching performed at beam-level or panel-level? | **Beam-level (including other UL TX beam candidates on the problematic panel)**: Xiaomi, Ericsson, Qualcomm, NTT Docomo, Intel, IDC, ZTE, Apple, Sony, Sharp, Nokia/NSB, Convida  **Panel-level (excluding all UL TX beam candidates on the problematic panel)**: OPPO, Sony, Samsung, Xiaomi, NTT Docomo, Lenovo/MoM, Intel, LG | This issue determines: 1) report content (CAT1), 2) candidates for alternative UL TX beam |
| 5.2 | CAT0 (MPE detection) | **No need for spec support**: MediaTek, Huawei/HiSi, Samsung, OPPO, Spreadtrum, APT, Sony, Sharp, Convida  **Wait until Rel.16 functionality is clear**: Ericsson  **Spec support (?)**: | A number of CAT0 proposals are re-categorized into CAT1 aspects since they either represent reporting content or triggering condition.  For condition-based triggering, the metric and threshold mechanisms can be decided later (e.g. BFR/partial BFR-like threshold, L1-RSRP/SINR threshold, Rel.16 PHR).  Early observation suggests that CAT0 is not needed and can be a part of CAT1 if UE-initiated condition-based approach is agreed.  Issue #5.3 on content (especially reporting alternate UL beam/panel) will have to be considered jointly with issue #4.7. This also depends on the conclusion on issue #4.1 and #5.1.  CAT1: Can UE-initiated co-exist with NW-triggered (input from NTT Docomo)? |
| 5.3 | CAT1 (UE reporting): triggering | **No need for spec support:** Spreadtrum, OPPO  **Wait until Rel.16 functionality is clear**: Ericsson,  **UE-initiated condition-based**: Huawei/HiSi, Samsung, CATT, Nokia/NSB, Sony, LGE, Qualcomm, NTT Docomo, ZTE, [Intel], Xiaomi, MediaTek, Apple, Convida  **UE-initiated without condition**:  **NW-triggered**: NTT Docomo, Nokia/NSB (configuration and activation/triggering of reporting) |
| CAT1 (UE reporting): content | **No need for spec support:** Spreadtrum  **Wait until Rel.16 functionality is clear**: Ericsson  **Beam group indication**: IDC  **MPE event indication**: Nokia/NSB, Samsung, LG  **CRI/SSBRI associated alternate UL panel and/or TX beam**: CATT, CMCC, Samsung, MediaTek, Intel, NTT Docomo, Qualcomm, Fraunhofer IIS/HHI, ZTE, Nokia/NSB, Apple, Sony, Ericsson, APT, Xiaomi, LG, Sharp  **L1-RSRP (companion of CRI/SSBRI)**: Apple, Samsung, [Ericsson], Nokia/NSB  **P-MPR**: Apple, Huawei/HiSi, IDC, vivo, Sony, Xiaomi, NTT Docomo (beam/panel specific), Nokia/NSB, CMCC, ZTE (beam/panel specific), Qualcomm, OPPO, Lenovo/MoM  **Pcmax**: Apple  **Virtual PHR**: Apple, ZTE, Nokia/NSB, Convida |
| 5.4 | CAT2 (NW signaling in response to UE reporting) | **No need for spec support (beyond separate UL beam indication):** Spreadtrum, OPPO, MediaTek, APT, Convida  **gNB confirmation (ACK)**: IDC, NTT Docomo, Samsung  **Spec support for UE behavior during/after MPE event reporting**: Nokia/NSB | Note: The support of separate UL beam indication from DL has been agreed in RAN1#102-e (issue 1b). The scheme is to be decided (Alt1 vs 2-1 vs 2-2) |
|  |  |  |  |

Based on the previous inputs, it seems that one possible way to proceed is to address the UE reporting first (which not only involves MPE mitigation, but also MP-UE aspects) – following the suggestion from some companies (cf. R1-2008147).

**Proposal 5.A**: On UE reporting for MPE mitigation for Rel.17:

* Support SSBRI/CRI indicating an alternative UE panel or TX beam for UL transmission
* Any additional reporting: down-select from the following in RAN1#104-e
  + Alt0: no additional reporting
  + Alt1: additional reporting
    - e.g. L1-RSRP, P-MPR, PHR, Pcmax, etc.

Table 10 Additional inputs for round-2 discussion: issue 5 proposal 5.A

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| **Company** | **Input** |
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* 1. Issue 6 (beam refinement/tracking)

Table 11 Summary: issue 6

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| --- | --- | --- |
| **#** | **Issue** | **Companies** |
| 6.1 | Beam measurement and reporting enhancement via RACH for initial access (e.g. RO for measurement and MSG3 for reporting) | AT&T, Qualcomm, Samsung, CMCC, Xiaomi, Sony |
| 6.2 | Improving efficiency (latency, overhead) of beam refinement:   * Enabling joint DL TX and RX beam refinement/tracking (P2+P3) * Additional UE report to aid P1/P2/P3 related measurement/report configuration (triggering frequency or periodicity) | Apple (CSI-RS based), Samsung (CSI-RS based), Intel (using SRS/CRI), Qualcomm (e.g. reporting rate of beam direction change) |
| 6.3 | Beam management with reduced DL signaling:   * Dynamic beam update based on beam report (without beam indication) * Dynamic beam measurement and report triggered by beam indication (without CSI-RS/CSI triggering) * Configuring/indicating to UE multiple SSBs for beam tracking * Semi-static/pre-planned (RRC based) beam transition (for, e.g. isolated HST deployment) * Reducing activation delay of TCI states (via storing QCL properties of a subset of source RSs for a time period) | Futurewei, Nokia/NSB, Samsung, Apple, Intel , NTT Docomo , Qualcomm, Xiaomi, Ericsson, Sharp |
|  |  |  |

From moderator perspective, proposal 6.A has been stable and is (almost) ready for endorsement.

* Regarding some comments on priority, as this is a study effort for now, the progress is based on the level of interest from companies. It is clearly understood that the other five issues take higher precedence than issue 6 since the associated work has been quite well defined.
* Regarding some comments on initial access, there is a parallel discussion in CovEnh WI (and agreement to work on this). Some discussion in the December RAN is expected to resolve whether this enhancement is to be worked on in FeMIMO or CovEnh. For now, it is included here since it is assumed that the expertise resides within the MIMO collective ☺

**Proposal 6.A**: Investigate and, if needed, specify *at least* the following enhancements for beam refinement/tracking in Rel.17 assuming the unified TCI framework (issue 1):

* Beam measurement and reporting enhancement via RACH during initial access (e.g. RO for measurement and MSG3 for reporting)
* Improving efficiency (latency and/or overhead) of beam refinement:
  + Enabling joint DL TX and RX beam refinement/tracking (P2+P3)
  + Additional UE report to aid P1/P2/P3 related measurement/report configuration (triggering frequency or periodicity)
* Beam management with reduced DL signaling:
  + Dynamic beam update based on beam report (without beam indication)
  + Dynamic beam measurement and report triggered by beam indication (without CSI-RS/CSI triggering)
  + Configuring/indicating to UE multiple SSBs for beam tracking
  + Semi-static/pre-planned (RRC based) beam transition (for, e.g. isolated HST deployment)
  + Reducing activation delay of TCI states (via storing QCL properties of a subset of source RSs for a time period)

Interested companies are encouraged to provide additional inputs (if any) on proposal 6.A.

Table 12 Additional inputs for round-2 discussion: issue 6 proposal 6.A

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| **Company** | **Input** |
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Appendix A: Agreements in RAN1#102-e

Issue 1

* [Issue 1] For Rel.17 NR FeMIMO, on the unified TCI framework
  1. Support joint TCI for DL and UL based on and analogous to Rel.15/16 DL TCI framework
     + The term “TCI” at least comprises a TCI state that includes at least one source RS to provide a reference (UE assumption) for determining QCL and/or spatial filter
     + The source reference signal(s) in M TCIs provide common QCL information at least for UE-dedicated reception on PDSCH and all or subset of CORESETs in a CC
       - FFS: Optionally this common QCL information can also apply to CSI-RS resource for CSI, CSI-RS resource for BM, and CSI-RS for tracking
       - FFS: Applicability on PDSCH includes PDSCH default beam
       - Working Assumption: Select between M=1 and M>=1
     + The source reference signal(s) in N TCIs provide a reference for determining common UL TX spatial filter(s) at least for dynamic-grant/configured-grant based PUSCH, all or subset of dedicated PUCCH resources in a CC,
       - Optionally, this UL TX spatial filter can also apply to all SRS resources in resource set(s) configured for antenna switching/codebook-based/non-codebook-based UL transmissions
       - FFS: applicability of this UL TX spatial filter to SRS configured for beam management (BM)
       - FFS: PUSCH port determination based on the TCI, e.g., to be mapped with SRS ports analogous to Rel.15/16
       - Working Assumption: Select between N=1 and N>=1
     + FFS: extension to common QCL information applied to only some of the CORESETs or PUCCH resources in a CC, e.g. for mTRP
     + FFS: When used for the purpose of joint beam indication for UL and DL, whether a joint TCI pool for DL and UL dedicated for the purpose is used, or the same TCI pool as that used for the purpose of separate DL/UL beam indication is used
     + Note: The resulting beam indication directly refers to the associated source RS(s)
     + FFS (RAN1#103-e): Details on extension to intra- and inter-band CA
     + FFS (RAN1#103-e): The supported number of active TCI states considering factors such as multi-TRP and issue 6
     + FFS (RAN1#103-e): Applicable QCL types, and co-existence with DL TCI and spatial relation indication in Rel.15/16
  2. In RAN1#103-e, investigate, for the purpose of down selection, the following alternatives for accommodating the case of separate beam indication for UL and DL
     + Alt1. Utilize the joint TCI to include references for both DL and UL beams
     + Alt2. Utilize two separate TCI states, one for DL and one for UL. The TCI state for the DL is the same as agreed in 1a. The TCI state for the UL can be newly introduced.
       - Alt 2-1: The UL TCI state is taken from the same pool of TCI states as the DL TCI state
       - Alt 2-2: The UL TCI state is taken from another pool of TCI states than the DL TCI state
     + Note: The resulting beam indication directly refers to the associated source RS(s)
     + FFS (RAN1#103-e): Details on extension to intra- and inter-band CA
     + Note: This may be related to issue 5 as well as other reasons for different TCIs such as network flexibility/scheduling
  3. Support the use of SSB/CSI-RS for BM and/or SRS for BM as source RS to determine a UL TX spatial filter in the unified TCI framework
     + Whether the UL TX spatial filter corresponds to UL TCI (separate from DL TCI) depends on the outcome of 1b) above
     + FFS: Support the use of non-BM CSI-RS and/or non-BM SRS in addition
  4. In RAN1#103-e, decide if SRS for BM can be configured as a source RS to represent a DL RX spatial filter in the unified TCI framework
  5. In RAN1#103-e, decide/finalize all other parameters included in or concurrent with (but not included in) the TCI, e.g. UL-PC-related parameters (involving P0/alpha, PL RS, and/or closed loop index), UL-timing-related parameters
  6. In RAN1#103-e, identify issues pertaining to alignment between DL and UL default beam assumptions using the unified TCI framework

Issue 2

* [Issue 2] For Rel.17 NR FeMIMO, on L1/L2-centric inter-cell mobility:
  1. In RAN1#103-e, finalize scope and use cases for L1/L2-centric inter-cell mobility, including:
     + Applicability in various non-CA and CA setups such as intra-band and inter-band CA
     + Use cases in comparison to Rel.15 L3-based handover (HO) taking into account potential extension of DAPS-based Rel.16 mobility enhancement to FR2-FR2 HO
     + The extent of RAN2 impact (MAC CE, RRC, user plane protocols)
     + Network architecture, e.g. NSA vs. SA, inter-RAT scenarios
  2. In RAN1#103-e, depending on the outcome of 2a), further identify additional components –along with the associated alternatives –required for supporting inter-cell mobility based on the same unified TCI framework as that for intra-cell mobility (including dynamic TCI state update signaling), including
     + Method(s) for incorporating non-serving cell information associated with TCI
     + Method(s) for DL measurements and UE reporting (e.g. L1-RSRP) associated with non-serving cell(s)
     + UE behavior for reception of signals and non-UE-specific control and data channels associated with non-serving cell(s)
     + UL-related enhancements, e.g. related to RA procedure including TA
     + Beam-level event-driven mechanism for L1/L2-centric inter-cell mobility

Issue 3

* [Issue 3] For Rel.17 NR FeMIMO, on dynamic TCI state update signaling medium:
  1. In RAN1#103-e, investigate, for the purpose of down selection, the following alternatives:
     + Alt1. DCI
     + Alt2. MAC CE
     + Note: Combination between DCI and MAC CE for, e.g. different use cases or control information partitioning can also be considered
     + Note: The study should consider factors such as feasibility for pertinent use cases, performance (based on at least the agreed EVM), overhead (including PDCCH capacity), latency, flexibility, reliability including the support of retransmission
     + Note: This may be related to outcome of issue 1a), 1b), and 6a)
  2. In RAN1#103-e, depending on the outcome of 3a), identify candidates for more detailed design issues for the dynamic TCI state update such as
     + Exact content
     + Signaling format
     + Reliability aspects including the support of retransmission
     + Extensions, including the support of UE-group (in contrast to UE-dedicated) signaling

Issue 4

* [Issue 4] For Rel.17 NR FeMIMO, on MP-UE assumption to facilitate fast UL panel selection:
  1. The following assumptions are used:
     + In terms of RF functionality, a UE panel comprises a collection of TXRUs that is able to generate one analog beam (one beam may correspond to two antenna ports if dual-polarized array is used)
     + UE panels can constitute the same as well as different number of antenna ports, number of beams, and EIRP
     + No beam correspondence across different UE panels
     + FFS: For each UE panel, it can comprise an independent unit of PC, FFT timing window, and/or TA.
     + FFS: Same or different sets of UE panels can be used for DL reception and UL transmission, respectively
  2. In RAN1#103-e, identify candidate use cases including MPE, and consider remaining aspects if use cases are identified
  3. In RAN1#103-e, identify candidate signaling schemes for the following:
     + NW to MP-UE (taking into account potential extension of the unified TCI framework in issue 1)
     + MP-UE to NW

Issue 5

* [Issue 5] For Rel.17 NR FeMIMO, on MPE mitigation (that is, minimizing the UL coverage loss due to the UE having to meet the MPE regulation), in RAN1#103-e:
  1. If needed, identify candidate solutions to be down-selected in future meeting(s). The following sub-categories can be used:
     + CAT0. The need for specification support for MPE event detection and, if needed, candidate solutions
     + CAT1. The need for UE reporting associated with an MPE and/or a potential/anticipated MPE event if the UE selects a certain UL spatial resource, e.g., corresponding to DL or UL RS
     + CAT2. The need for NW signaling in response to the reported MPE event (taking into account issue 1) and UE behavior after receiving the NW signaling
     + Note: RAN4 has agreed to specify P-MPR reporting (cf. CRs for TS 38.101/102/133) which can be used as a baseline scheme for further enhancement
     + Note: This may be related to outcome of issue 4b)
  2. Companies are encouraged to submit evaluation results based on the agreed EVM to justify the benefits of the candidate solutions

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