**3GPP TSG RAN WG1 #103-e R1-2008147**

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

**Agenda item:** 8.1.1

**Source:** Moderator (Samsung)

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

**Document for:** Discussion and Decision

**Change history – Moderator versions (to be removed in final version)**

|  |  |  |
| --- | --- | --- |
| **Version** | **Add companies’ inputs** | **Moderator changes** |
| 04 | Vivo, ZTE, Qualcomm, OPPO, Xiaomi, Samsung | Additional observation, proposal 2.1 |
|  |  |  |
|  |  |  |

1. 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:

|  |
| --- |
| * 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 |

This summary includes the following:

* Issue categorization
* Observation and proposal
* Summary of current companies’ positions on each of the aspects within the category

1. Issue Categorization (from RAN1#102-e)

Issues raised by interested companies are organized as follows to identify pertinent aspects (including design components). This is not intended to be an exhaustive list of alternatives, but rather a skeleton to facilitate planning and progress tracking from meeting to meeting. The details on each item will be hashed out as the work progresses.

Table 1 Category of issues

|  |
| --- |
| 1. **Unified TCI framework** – by means of extending the Rel.15/16 DL TCI framework (e.g. TCI state definition)    1. Design for UL common TCI       1. Goal: utilize same unified design as DL TCI, specify UL TCI framework to facilitate common TCI state update for UL (data, PUCCH, SRS)       2. Including UL PC, timing control, PL RS, and/or default UL common beam    2. Design for DL common TCI       1. Goal: identify and, if needed, specify potential refinement on Rel.15/16 DL TCI framework to facilitate common TCI state update for DL (data and DL assignment of the same UE)       2. Including default DL common beam    3. Additional QCL Type-D relations for TCI state definition       1. Goal: if supported, facilitate extended use of DL RS (e.g. SSB, CSI-RS) for UL and UL RS (e.g. SRS) for DL    4. Facilitating combined/joint and separate TCI for DL and UL:       1. Goal 1: when beam correspondence is assumed (common scenario), specify TCI framework to facilitate common TCI state update for DL and UL       2. Goal 2: when beam correspondence is not assumed (e.g. MPE event), facilitate separate TCI state updates for DL and UL   *Note: the following factors should be considered in the above design aspects*   * + - *CA and cross-carrier scheduling operation (e.g. inter- and intra-band CA, FR1/FR2 CCS)*     - *Beam correspondence assumption*     - *When applicable, performance assessment based on the agreed EVM*  1. **L1/L2-centric inter-cell mobility**     1. The need for and/or the applicability and scope of L1-/L2-centric inter-cell mobility:       1. Goal: assess the need for and/or the applicability (use cases) and scope of L1/L2-centric inter-cell mobility (as an enhancement on the Rel.15/16 L3-based approach)    2. Method of enabling L1/L2-based inter-cell mobility:       1. Goal: select the type of information pertinent to non-serving cell(s) in TCI state to facilitate inter-cell mobility operation, e.g. PCI, SSB/TRS indicator,TAGs, L1-RSRP report for RS in a neighboring cell   *Note: the following factors should be considered in the above design aspects*   * + - *CA and cross-carrier scheduling operation (e.g. inter- and intra-band CA, FR1/FR2 CCS)*     - *Beam correspondence assumption*     - *When applicable, performance assessment based on the agreed EVM*  1. **Dynamic TCI state update signaling medium** for common TCI state update operation    1. Signaling medium: L1 control signaling (DCI-based on PDCCH) and/or MAC CE       1. Goal: select the medium and the associated detailed design used for signaling TCI state update       2. This includes DCI format when applicable, reliability (HARQ-ACK and/or repetition), UE-specific vs. UE-group, 1-part vs. 2-part signaling, timing aspect    2. Exact content:       1. Goal: define list of parameters included in the TCI state update (supporting multiple formats is possible)       2. This includes (a) separate DL and UL (DL-only and UL-only), (b) Combined joint DL and UL   *Note: the following factors should be considered in the above design aspects*   * + - *CA and cross-carrier scheduling operation (e.g. inter- and intra-band CA, FR1/FR2 CCS)*     - *Beam correspondence assumption*     - *When applicable, performance assessment based on the agreed EVM at high-speed scenarios*  1. **Extension of UL TCI for UE with (capable of) multiple panels** to facilitate UL fast panel selection, given the unified TCI framework design (cf. the above aspect 1 and 3)    1. Mechanism to identify a UE panel:       1. Goal: Assess whether resource ID or resource set ID (SRS, CSI-RS, ...) is sufficient or an explicit (new) panel ID is needed    2. Signaling mechanism to enable UL fast panel selection,       1. Goal 1: assess needed signaling from UE to NW, e.g. to indicate multi-panel capability, UE reporting       2. Goal 2: extending UL TCI state update mechanism for various scenarios for UL fast panel selection, e.g. if supported, DL and UL TCI state update are (a) common, (b) separate;    3. The need for panel-specific timing and power control enhancements in relation to panel indication and unified TCI framework design       1. Goal: assess the need for panel-specific timing and power control and, if needed, the associated specification features   *Note: the following factors should be considered in the above design aspects*   * + - *CA and cross-carrier scheduling operation (e.g. inter- and intra-band CA, FR1/FR2 CCS)*     - *The use of UE panels for both DL reception and UL transmission, including the need for UE reporting and NW signaling*     - *Beam correspondence assumption*  1. **MPE mitigation -** given the unified TCI framework design and multi-panel UE support (cf. the above aspect 1, 3, and 4)    1. The need for enhancement(s) to reduce UL coverage loss due to meeting MPE regulation       1. Goal: assess the need based on a list of candidate schemes    2. Method of enabling MPE mitigation:       1. Goal: scheme selection for MPE mitigation   *Note: the following factors should be considered in the above design aspects*   * + - *Beam correspondence assumption*     - *Performance assessment based on the agreed EVM*     - *Support for fast panel selection on MP-UE*  1. **Advanced beam refinement and tracking** targeting high-mobility and large number of configured TCI states **-** given the unified TCI framework design for intra- and L1/L2-centric inter-cell mobility, and multi-panel UE support (cf. the above aspect 1, 2, 3, and 4)    1. Overhead and latency reduction of beam refinement       1. Goal: evaluate and select schemes (including NW signaling and configuration as well as UE signaling) to enable faster gNB/UE beam refinement       2. Refinement is understood as selecting narrower (more spatially precise) beam from a set of candidate beams (gNB and/or UE beams, jointly or separately) which also includes beam sweeping    2. Overhead and latency reduction of beam tracking       1. Goal: evaluate and select schemes (including NW signaling and configuration as well as UE signaling) to enable faster gNB and/or UE beam tracking       2. Tracking is understood as prompt/predictive response to the change in propagation link   *Note: the following factors should be considered in the above design aspects*   * + - *CA and cross-carrier scheduling operation (e.g. inter- and intra-band CA, FR1/FR2 CCS)*     - *Beam correspondence assumption*     - *Performance assessment based on the agreed EVM* |

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

The summary is based on the issue categorization in Table 1. 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 2 Summary: issue 1

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **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 * **No**: Huawei/HiSi   Some CSI-RS resource(s) for BM:   * **Yes**: OPPO, Samsung, Qualcomm, ZTE, NTT Docomo * **No**: Huawei/HiSi, vivo, APT   CSI-RS for tracking:   * **Yes**: vivo, Nokia/NSB, Spreadtrum, Convida, Fraunhofer IIS/HHI, Qualcomm, ZTE * **No**: Huawei/HiSi, MediaTek, OPPO   Periodic CSI-RS:   * **Yes**: Apple, Qualcomm (separate update), NTT Docomo (prefer resource switching to enable resource sharing across UEs) * **No**: ZTE | For common QCL: some CSI-RS resource(s) for BM can be used for RX beam refinement (P3) |
| 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 * **No**: Huawei/HiSi, APT, Spreadtrum, Convida, NTT Docomo |  |
| 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, ZTE  **Max=2 for mTRP**: Nokia/NSB, Fraunhofer IIS/HHI, Samsung, Apple (M=2), AT&T  **Max>1**: Sharp, NTT Docomo (to enable DCI based), Futurewei, IDC, vivo (multiple beams per TRP, Max=4), ZTE, Qualcomm | 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 |
| 1.4 | TCI state applicability to a subset of CORESETs (in addition to all CORESETs) | **Yes**: LGE, Nokia/NSB, Ericsson, Qualcomm, NTT Docomo  **No**: |  |
| 1.5 | TCI state applicability to a subset of PUCCHs (in addition to all PUCCHs) | **Yes**: LGE, Nokia/NSB, Ericsson, Qualcomm  **No**: |  |
| 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  **No**: -- |  |
| 1.7 | Separate UL and DL beam indication for 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**: CATT, AT&T, Xiaomi, Nokia/NSB, Intel, APT  **Alt 2-2**: Futurewei, CMCC, Nokia/NSB, Sony, Fraunhofer IIS/HHI, Xiaomi, APT, Ericsson, AT&T, Qualcomm |  |
| 1.8 | Additional source RS types for UL TX spatial filter | SSB:   * **Yes**: vivo, Qualcomm, NTT Docomo * **No**: Huawei/HiSi, MediaTek   Non-BM CSI-RS   * **Yes**: Huawei/HiSi, vivo, Nokia/NSB, Ericsson, Qualcomm * **No**: Convida   Non-BM SRS   * **Yes**: Spreadtrum, Qualcomm * **No**: Convida   DL channels: Fraunhofer IIS/HHI |  |
| 1.9 | SRS for BM as source RS for DL RX spatial filter | **Yes**: IDC, vivo, Samsung, Sony, Nokia/NSB, Convida  **No**: Ericsson, ZTE |  |
| 1.10 | Additional parameters in unified TCI | UL PC parameters in unified TCI (P0/alpha, CL index)   * **Yes**: IDC, Lenovo/MotM, Futurewei, CMCC, Samsung, Qualcomm, ZTE * **No**: Huawei/HiSi   PL RS:   * **Yes**: IDC, vivo, ZTE, OPPO, Lenovo/MotM, Qualcomm, Fraunhofer IIS/HHI, Futurewei, Samsung * **No**:   UL timing parameters   * **Yes**: LGE (panel-specific) * **No**: Apple,OPPO |  |
| 1.11 | Support default QCL/spatial relation for joint/common TCI | **Yes**: Huawei/HiSi, vivo (extend R15/R16), CATT, Fraunhofer IIS/HHI, NTT Docomo, Ericsson (CORESET with lowest ID), Sharp, Spreadtrum, Qualcomm, Xiaomi  **No (not needed)**: Nokia/NSB, MediaTek,OPPO | 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 |
|  |  |  |  |

**Proposal 1.1**: On Rel.17 unified TCI framework, support common TCI state (including TCI state activation) across a set of configured CCs for intra-band and inter-band CA

**Proposal 1.2**: [need more inputs ...]

**Conclusion 1.1**: [need more inputs ...]

Table 3 Additional inputs: issue 1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Qualcomm | Please find the added view per issue in the above list. Support FL’s proposal. |
| Xiaomi | Please find the added view for some issues in the above list. Support the proposal. |
|  |  |
| Samsung | In general, supportive of proposal 1.1. For the case of intra-band CA, it seems reasonable to have a common TCI state across the carriers. For the case of inter-band CA, having a common TCI state across carriers is a good starting. However, we would like to add FFS for separate TCI states in case of inter-band CA. |
| NTT Docomo | For 1.10, if the unified TCI is for UL TCI state only, we think it is reasonable to include UL PC/PL-RS parameters in UL TCI state configuration. However, if the unified TCI is for both DL and UL TCI state, we think we can consider the association configuration between UL PC/PL-RS parameters and the unified TCI configuration. |

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

Table 4 Summary: issue 2

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 2.1 | Use cases: network architecture | **NSA with common LTE anchor**: Samsung, Ericsson, Qualcomm  **SA**: Samsung, Qualcomm |  |
| 2.2 | Use cases: CA aspects (in addition to non-CA) | **Include only intra-band CA**: IDC, Samsung, Nokia/NSB  **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, NTT Docomo |  |
| 2.4 | Use cases: sTRP and mTRP | **Only sTRP**: Nokia/NSB, Samsung, OPPO |  |
| 2.4 | Use cases: DU aspect | **Only cells in the same DU**: Samsung, Qualcomm, ZTE, NTT Docomo |  |
| 2.5 | Scope of enhancements:  EG1. Minimum RAN2 impact: TCI and measurement/reporting  EG2. Timing offset issues, TA  EG3. RA/RACH | **EG1 only**: Samsung, Ericsson, Nokia/NSB, Apple, OPPO , Xiaomi  **EG1+EG2**: vivo, Qualcomm, Samsung , NTT Docomo  **EG1+EG2+EG3**: Intel, ASUSTeK, CATT, CMCC, Qualcomm |  |
| 2.6 | Method(s) for incorporating non-serving cell info in TCI | **Indicate RS of non-serving cell as QCL source**: IDC, ZTE, Samsung, Nokia, Lenovo, ASUSTeK, Qualcomm, OPPO, Xiaomi, NTT Docomo  **Include PCI in TCI**: vivo, CATT, Sony, Xiaomi, Ericsson, NTT Docomo | Whether these two are competing alternatives or not may need some discussion |
|  |  |  |  |
|  |  |  |  |

**Proposal 2.1**: On Rel.17 enhancements to enable L1/L2-centric intercell-mobility:

* The following use cases are assumed:
  + Network architecture: NSA with common LTE anchor [and SA]
  + Intra-band CA [and include NR-PSCell]
    - FFS: If inter-band CA is also included
  + Only cells in the same DU
  + Intra-frequency and intra-RAT (excluding inter-frequency and inter-RAT)
  + Only single-TRP cells
* The following scope is assumed:
  + ...

**Proposal 2.2**: [need more inputs ...]

Table 5 Additional inputs: issue 2

|  |  |
| --- | --- |
| **Company** | **Input** |
| Qualcomm | Please find the added view per issue in the above list |
| Xiaomi | Please find the added view for some issues in the above list. |

* 1. Issue 3 (beam indication signaling medium)

Table 6 Summary: issue 3

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 3.1 | Beam indication medium for common TCI state update (unified TCI framework)  Alt1. DCI  Alt2. MAC CE | Alt1: Futurewei, IDC, ZTE, CATT, OPPO, Samsung, Sony, Apple (also with MAC CE for other uses case(s)), Nokia/NSB, NEC, MediaTek, Sharp, Spreadtrum, Ericsson, AT&T, NTT Docomo, Verizon Wireless, [Intel], Qualcomm, [vivo]  Alt2: Huawei/HiSi, [vivo], Fraunhofer IIS/HHI, Lenovo/MotM, Xiaomi, Convida | Majority view: Alt1  Some Alt1 companies propose to at least consider group-common DCI (Futurewei, Samsung, MediaTek, Intel, NTT Docomo, Qualcomm) but some raise concern (OPPO, Ericsson, Nokia/NSB, IDC, Apple). No Alt.1 companies raise concern on UE-specific DCI.  A number of Alt1 companies propose using MAC CE for activating TCI states similar to Rel.15/16 (as a compromise, to reduce # TCI codepoints in DCI}: Apple, Samsung, MediaTek, NTT Docomo, Qualcomm  A number of Alt1 companies propose a mechanism for UE to send an ACK upon successful decoding for reliability: Futurewei, ZTE, Apple, OPPO, Samsung, Nokia/NSB, NEC, NTT Docomo, Qualcomm |
| 3.2 | Detailed design aspects of DCI-based beam indication (Alt1 in 3.1) | The following issues are identified:   1. UE-specific DCI format (reuse some existing format(s), new design) and ACK mechanism (implicit from DL-related DCI, Rel.15 SPS PDSCH release): Futurewei, ZTE, CATT, NTT Docomo, Ericsson Samsung, Nokia/NSB, NEC, Qualcomm 2. TCI state activation time including UE capability issue: Apple, ZTE, Samsung, NEC, Qualcomm 3. DCI content: Futurewei, OPPO, Samsung, NTT Docomo 4. TCI state assumption/update for common beam indication DCI: vivo 5. Max # activated TCI states: Futurewei 6. Separate UL beam indication (depending on issue 1 /6 decision): NTT Docomo, Apple | |
|  |  |  |  |

**Proposal 3.1**: On beam indication signaling medium to support common TCI state update in Rel.17 unified TCI framework:

* Support L1-based beam indication (TCI state update) with UE-specific (unicast) DCI
  + In addition, support a mechanism for UE to acknowledge successful decoding of TCI state update
    - Note: Exact acknowledgment mechanism is TBD depending on the selected DCI format
  + The updated TCI state applies at least to UE-dedicated reception on UE-specific CORESETs and the PDSCH scheduled by these CORESETs
    - FFS: TCI state assumption/update of the beam indication UE-specific DCI
  + When joint DL and UL beam indication is configured, the updated TCI state also applies to dynamic-grant/configured-grant based PUSCH and dedicated PUCCH resources
* Support activation of multiple TCI states via MAC CE analogous to Rel.15/16

**Proposal 3.2**: In RAN1#103-e, further discuss and identify alternatives for the following design aspects of common TCI state update, to be down selected *by* RAN1#104-e:

* Aspect I: UE-specific DCI format and its associated ACK mechanism
* Aspect II: TCI state activation time including UE capability issue
* Aspect III: DCI content
* Aspect IV: TCI state assumption/update for common beam indication DCI
* Aspect V: Max # activated TCI states (note: baseline = 8 from Rel.15/16)
* Aspect VI: Separate UL beam indication

Table 7 Additional inputs: issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| Qualcomm | Please find the added view per issue in the above list. Support FL’s proposal #3.1.  For FL’s proposal #3.2, we prefer to prioritize issue I and II. |
| Vivo | In general, can be supportive of FL proposal 3.1 with the following issues considered/addressed in the text of proposal 3.1:  1) The beam for the ACK of beam indication DCI may need to follow the beam of DCI itself. However, the beam of the DCI still needs further discussion (with the added FFS above). Thus the beam of the PUCCH and PUSCH for ACK also needs FFS. 2) For the dedicated PUSCH/PUCCH scheduled/triggered by non-UE specific CORESETs, the beam may not need to be updated by the DCI since this may be used for RRC reconfiguration related procedure. The beam for these UL transmission may also need to be robust.  So, we suggest the following refinement of the text:   * The updated TCI state applies at least to UE-dedicated reception on UE-specific CORESETs (other than the CORESETs for the beam indication DCI) and the PDSCH scheduled by these CORESETs   + FFS: TCI state assumption/update of the beam indication UE-specific DCI * When joint DL and UL beam indication is configured, the updated TCI state also applies to dynamic-grant/configured-grant based PUSCH and dedicated PUCCH resources (other than the PUSCH scheduled/activated and PUCCH transmission triggered by non-UE-specific CORESETs)   + FFS: TCI state assumption/update of PUSCH/PUCCH resources for the acknowledgment of beam indication DCI |
| Samsung | Support FL proposal 3.1. This provides better reliability, lower latency and less overhead than MAC CE based beam indication. Our simulations indicate an average gain of up to 12% in user throughput. To improve reliability of DCI-based TCI indication, we support having HARQ-ACK feedback for DCI. |
| NTT Docomo | Support FL’s proposal #3.1.  For FL’s proposal #3.2, we prefer to prioritize issue I and III. |

* 1. Issue 4 (MP-UE)

Table 8 Summary: issue 4

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **Moderator notes/observation** |
| 4.1 | Use cases for fast UL panel selection:  Opt1. MPE mitigation  Opt2. UE power saving (note: different panels can have different # ports)  Opt3. UL mTRP  Opt4. UL interference management  Opt5. Support different configurations across panels | **Opt1**: vivo, Samsung, Fraunhofer IIS/HHI, Intel, Nokia/NSB, MediaTek, Qualcomm, Xiaomi, NTT Docomo  **Opt2**: Apple, OPPO, Samsung, Qualcomm  **Opt3**: vivo, [Intel]  Opt4: Qualcomm, NTT Docomo  Opt5: Qualcomm, NTT Docomo | Whether **Opt3** should be addressed in MB (item 1) or mTRP (item 2a/c) will need to be discussed. |
| 4.2 | Whether to include enhancements for slow UL panel de/activation (for UE power saving) | **Yes**: vivo, OPPO, Sony, NTT Docomo  **No**: Qualcomm  **Discuss with mTRP**: MediaTek | Note: As commented in RAN1#102-e by some companies, since Rel.17 WID only mentions fast panel selection, whether to include this enhancement needs to be agreed first. |
| 4.3 | Whether to support per-panel UL PC | **Yes**: Sony, Fraunhofer IIS/HHI, Huawei/HiSi, LGE, Nokia/NSB  **No**: OPPO (explicit per-panel UL PC is not needed since PC parameters is associated with uplink spatial setting)  **Discuss in mTRP**: MediaTek |  |
| 4.4 | Whether to support per-panel UL TA | **Yes**: Sony, Fraunhofer IIS/HHI, Huawei/HiSi, LGE, Nokia/NSB  **No**: OPPO  **Discuss in mTRP**: MediaTek |  |
| 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  **No**: Huawei/HiSi, CATT |  |
| 4.6 | NW to MP-UE signaling | **Panel selection/indication**: NTT Docomo, Spreadtrum, Lenovo/MotM, Xiaomi, APT, CATT, IDC, Nokia/NSB, Samsung (MPE), Qualcomm, ZTE | Note: What constitutes a panel (functionally) has been defined/agreed in RAN1#102-e.  Note: First establish signaling requirements, then detailed mechanisms (including the need for a new/explicit panel ID vs. source RS/set indication, relation between panel indication with TCI framework) can be decided later based on the agreed panel definition. |
| 4.7 | MP-UE to NW signaling | **Panel selection/indication**: Apple (antenna port group), CMCC, IDC, OPPO, MediaTek, Lenovo/MotM, Nokia/NSB, Samsung (MPE), ZTE, NTT Docomo, vivo, Spreadtrum, Qualcomm, Xiaomi  **Along with CRI/SSBRI**: Qualcomm, vivo, CMCC, NTT Docomo  **Along with panel CQI**: IDC  **UE reporting on currently activated panel(s)**: APT, NTT Docomo, Qualcomm |
| 4.8 | Miscellaneous | Study necessity of additional signaling for two-layer dual-polarized beam: Sony  Which side decides panel activation: Qualcomm (strongly prefer for high priority) | |
|  |  |  |  |

**Proposal 4.1**: [Use case(s) for fast UL panel selection, and whether to include slow panel de/activation... need more inputs]

**Proposal 4.2**: To facilitate fast UL panel selection for MP-UEs, *at least* the following features are supported in Rel.17:

* NW to MP-UE DL signaling on panel selection/indication
  + FFS: Detailed mechanism for panel indication including the need for a new/explicit panel ID and the relation between panel indication with TCI framework
* MP-UE to NW UL signaling (reporting) on panel-related indication
  + FFS: Detailed mechanism for panel indication including the need for a new/explicit panel ID and the relation between panel indication with TCI framework

**Proposal 4.3**: [UL PC/TA ... need more inputs]

**Proposal 4**: [DL RX and UL TX panels ... need more inputs]

Table 9 Additional inputs: issue 4

|  |  |
| --- | --- |
| **Company** | **Input** |
| Qualcomm | Please find the added view per issue in the above list. Support FL’s proposal.  Also added Opt. 4 and Opt. 5 for 4.1  Added one issue under Miscellaneous   * Which side decides panel activation (strongly prefer for high priority) |
| Xiaomi | Please find the added view for some issues in the above list. Support the proposal. |
|  |  |
| Samsung | In general supportive of FL proposal 4.2, but add the following to the 1st bullet: “Note: Depending on the outcome of unified TCI framework, additional NW to MP-UE DL signaling beyond beam indication may not be needed” |
| NTT Docomo | Please find our views in the above list. We support FL proposal 4.2. |

* 1. Issue 5 (MPE mitigation)

Table 10 Summary: issue 5

|  |  |  |  |
| --- | --- | --- | --- |
| **#** | **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  **Panel-level (excluding all UL TX beam candidates on the problematic panel)**: OPPO, Sony, Samsung, Xiaomi, NTT Docomo | 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  **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 #5.2 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. |
| 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  **UE-initiated without condition**:  **NW-triggered**: NTT Docomo |
| 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  **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  **L1-RSRP (companion of CRI/SSBRI)**: Apple, Samsung, [Ericsson]  **P-MPR**: Apple, Huawei/HiSi, IDC, vivo, Sony, Xiaomi, NTT Docomo (beam/panel specific), Nokia/NSB, CMCC, ZTE (beam/panel specific), Qualcomm,OPPO  **Pcmax**: Apple  **Virtual PHR**: Apple, ZTE |
| 5.4 | CAT2 (NW signaling in response to UE reporting) | **No need for spec support (beyond separate UL beam indication):** Spreadtrum, OPPO, MediaTek, [Nokia/NSB]  **gNB confirmation (ACK)**: IDC, NTT Docomo | 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) |
|  |  |  |  |

**Proposal 5.1**: [Switching ... need more inputs]

**Proposal 5.2**: [CAT0 ... need more inputs]

**Proposal 5.3**: On UE reporting for MPE mitigation, agree on the following for Rel.17:

* Support UE-initiated condition-based reporting
  + In RAN1#103-e, further discuss and identify alternatives for the condition(s) for down-selection by RAN1#104-e
* [CAT1 content ... need more inputs - # companies proposing alternate panel/beam reporting is large, but more discussion is needed in relation to #4.1, 4.7, and 5.1]

**Proposal 5.4**: [CAT2 ... need more inputs]

Table 11 Additional inputs: issue 5

|  |  |
| --- | --- |
| **Company** | **Input** |
| Qualcomm | Please find the added view per issue in the above list. Support FL’s proposal. |
| Xiaomi | Please find the added view for some issues in the above list. Support the proposal. |
| NTT Docomo | Please find our views in the above list. And we would like to also consider periodic/aperiodic UL panel/beam reporting configured by NW, to schedule/indicate a better UL panel/beam and to avoid MPE happening. |
|  |  |

* 1. Issue 6 (beam refinement/tracking)

Table 12 Summary: issue 6

|  |  |  |
| --- | --- | --- |
| **#** | **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, CATT,Xiaomi |
| 6.2 | Enabling joint DL TX and RX beam refinement/tracking (P2+P3) | Apple (CSI-RS based), Samsung (CSI-RS based), Intel (using SRS/CRI) |
| 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) | Futurewei, Nokia/NSB, Samsung, Apple, Intel , NTT Docomo , Qualcomm, Xiaomi |
| 6.4 | Reducing activation delay of TCI states (via storing QCL properties of a subset of source RSs for a time period) | Ericsson, Samsung, NTT Docomo |
| 6.5 | Additional UE report to aid P1/P2/P3 related measurement/report configuration (triggering frequency or periodicity) | Qualcomm (rate e.g. of beam direction change), Samsung |
|  |  |  |

**Proposal 6.1**: Investigate the following enhancements for beam refinement/tracking in Rel.17: [need inputs ...]

Table 13 Additional inputs: issue 6

|  |  |
| --- | --- |
| **Company** | **Input** |
| Qualcomm | Our preferred discussion priority is issue #5, #1, #3, #2, #4 |
| Xiaomi | Please find the added view for some issues in the above list. |
| Samsung | We are supportive of investigating all the above issues. Issue #6.2 and #6.5 can perhaps be combined |
|  |  |
|  |  |

* 1. Miscellaneous

Table 14 Summary: miscellaneous

|  |  |
| --- | --- |
| **Company** | **Input** |
| Apple | Joint SSB/CSI-RS: a new QCL-Type for 2 RSs with the same Tx beam |
| Nokia/NSB | P2 CSI-RS as QCL source for TRS |
| Lenovo/MotM | DCI or MAC CE for latency reduction  MAC CE to indicate assoc. NZP CSI-RS and SRS resource set for non-CB-based UL |
| MediaTek | MAC CE to indicate assoc. NZP CSI-RS and SRS resource set for non-CB-based UL  MAC CE based BFD/RLM RS update |
| Intel | QCL info between SSB and CSI-RS resource sets is indicated via MAC CE |
| NTT Docomo | P-SRS: increase #SRS resources or #SRS resource sets; MAC CE based spatial relation update |

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

# References

1. R1-2007546 Enhancement on multi-beam operation Futurewei
2. R1-2007586 Enhancements on multi-beam operation in Rel-17 Huawei, HiSilicon
3. R1-2007626 Discussions on multi-beam Enhancement Interdigital Inc.
4. R1-2007644 Further discussion on multi beam enhancement vivo
5. R1-2007763 Enhancements on multi-beam operation ZTE
6. R1-2007770 Further details on multi-beam and multi-TRP operation ZTE
7. R1-2007824 Discussion on enhancement on multi-beam operation CATT
8. R1-2008000 Enhancements on multi-beam operation CMCC
9. R1-2008148 Multi-beam enhancements Samsung
10. R1-2009367 Simulation results for multi-beam enhancements Samsung
11. R1-2008217 Enhancements on multi-beam operation OPPO
12. R1-2008755 Analysis of control signalling for multi-beam operation Dongquan OPPO Precision Elec.
13. R1-2008308 Enhancements on NR multi-beam operation AT&T
14. R1-2008346 Considerations on the enhancement of multi-beam operation Sony
15. R1-2008348 On beam management enhancement Apple
16. R1-2008573 Enhancements on multi-beam operation LG Electronics
17. R1-2008899 Enhancements on multi-beam operation Fraunhofer IIS, Fraunhofer HHI
18. R1-2008903 Enhancements on multi-beam operation Nokia, Nokia Shanghai Bell
19. R1-2008910 Enhancements on multi-beam operation Lenovo, Motorola Mobility
20. R1-2008943 Discussion on multi-beam operation NEC
21. R1-2008956 Enhancements on multi-beam operation Mediatek Inc.
22. R1-2008977 Enhancements on multi-beam operation Intel Corporation
23. R1-2009027 Enhancements on multi-beam operation Xiaomi
24. R1-2009060 Discussion on enhancements for multi-beam operation Asia Pacific Telecom co. Ltd
25. R1-2009141 Enhancements on multi-beam operation Spreadtrum Communications
26. R1-2009155 Discussion on multi-beam operation ASUSTeK
27. R1-2009158 Multi-beam enhancements Convida Wireless
28. R1-2009129 Enhancement on multi-beam operation Sharp
29. R1-2009132 Other enhancements for beam management Sharp
30. R1-2009174 Discussion on multi-beam operation NTT DOCOMO Inc.
31. R1-2009250 Enhancements on multi-beam operation Qualcomm Incorporated
32. R1-2009288 Enhancements on multi-beam operation Ericsson
33. R1-2009290 Additional simulation results on multi-beam operation Ericsson