**3GPP TSG RAN WG1 #109-e R1-2nnnnn**

**e-Meeting, May 9th – 20th, 2022**

**Source: Ad-Hoc Chair (AT&T)**

**Title: Session Notes of AI 8.16.1**

**Agenda Item:** **8.16.1**

**Document for:** **Endorsement**



#### 8.16.1 UE features for further enhancements on NR-MIMO

[109-e-R17-UE-features-MIMO-01] Email discussion on UE features for further enhancements on NR-MIMO – Ralf (AT&T)

* 1st check point for LS to RAN2: May 13
* Final check point for any remaining issues: May 20

**Agreement: Adopt the following changes highlighted in chromatic fonts, while keeping the yellow highlighting, if any, as shown**

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| 23. NR\_FeMIMO | 23-1-1b | Unified TCI with joint DL/UL TCI update for intra- [and inter-cell] beam management with more than one MAC-CE activated joint TCI state per CC | 1. TCI state indication ~~[mode]:~~ for update and activation ~~[in case of updates]~~ b) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_1/1\_2 with DL assignment) c) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_1/1\_2 without DL assignment) 2. ~~[~~The minimum beam application time ~~between PUCCH of ACK and the first slot~~ in Y symbols per SCS~~]~~ 3. The maximum number of MAC-CE activated joint TCI states per CC ~~[~~in a band~~] [in a band combination]~~ 4. ~~[The minimum time gap between the beam indication PDCCH and first slot where beam is applied]~~ | 23-1-1 | Yes |  | Unified TCI with joint DL/UL TCI update for intra- [and inter-cell] beam management with more than one MAC-CE activated joint TCI state per CC is not supported | Per band | n/a | n/a | n/a | Component 2 candidate values: {1, 2, 4, 7, 14, 28, 42, 56, 70, 84, 98, 112, 224, 336}, where {84, 98, 112, 224, 336 } only can be indicated in FR2  Component 3 candidate values: ~~[~~{2,3,4,5,6,7,8 ~~…~~}~~]~~  Note: The maximum number of MAC-CE activated joint TCI states across all CC(s) in a band for more than one MAC-CE activated joint TCI state is signaled in 23-1-1, component 5  Note: activated joint TCI state(s) include all PDCCH/PDSCH receptions and PUSCH/PUCCH | Optional with capability signalling |

* Note: Additional values for component 2 candidate values for FR 2-2 to be discussed in agenda item 8.16.2

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| 23. NR\_FeMIMO | 23-1-1 | Unified TCI with joint DL/UL TCI update for intra-cell ~~[and inter-cell]~~ beam management | 1. Joint DL/UL TCI update with their components: (configuration mechanism, QCL rules, applicable source and target signals) 2. WA: The maximum number of configured joint TCI states [per BWP per CC] [in a band] [in a band combination] 3. One MAC-CE activated joint TCI state per CC [in a band] [in a band combination] 4. TCI state indication [mode]: update and activation [in case of updates]a) MAC CE based TCI state indication [for one active TCI state] 5. The maximum number of MAC-CE activated joint TCI states across all CC(s) in a band |  | Yes |  | Unified TCI with joint DL/UL TCI update for intra-cell ~~[and inter-cell]~~ beam management is not supported | Per band | n/a | n/a | n/a | FFS: how to count the MAC-CE activated joint TCI    If a UE supports FG 23-1-1k, the signalled component values [(except component 5)] also apply to inter-cell beam management | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-1-1k | Unified TCI with joint DL/UL TCI update for inter-cell beam management | 1. Support of unified TCI with joint DL/UL TCI update for inter-cell beam management  [2. Support K additional MAC-CE indicated joint TCI states in PCell [in a band] [in a band combination]]  [3. Support K additional MAC-CE activated joint TCI states across all CC(s) in a band] |  | Yes |  | Unified TCI with joint DL/UL TCI update for inter-cell beam management is not supported | Per band | n/a | n/a | n/a | FFS: a UE that supports FG 23-1-1 must also support this FG | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-1-1b | Unified TCI with joint DL/UL TCI update for intra- ~~[~~and inter-cell~~]~~ beam management with more than one MAC-CE activated joint TCI state per CC | 1. TCI state indication for update and activation  b) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_1/1\_2 with DL assignment) c) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_1/1\_2 without DL assignment) 2. The minimum beam application time in Y symbols per SCS 3. The maximum number of MAC-CE activated joint TCI states per CC in a band | 23-1-1 | Yes |  | Unified TCI with joint DL/UL TCI update for intra- ~~[~~and inter-cell~~]~~ beam management with more than one MAC-CE activated joint TCI state per CC is not supported | Per band | n/a | n/a | n/a | Component 2 candidate values: {1, 2, 4, 7, 14, 28, 42, 56, 70, 84, 98, 112, 224, 336}, where {84, 98, 112, 224, 336 } only can be indicated in FR2  Component 3 candidate values: {2,3,4,5,6,7,8}  Note: The maximum number of MAC-CE activated joint TCI states across all CC(s) in a band for more than one MAC-CE activated joint TCI state is signaled in 23-1-1, component 5  Note: activated joint TCI state(s) include all PDCCH/PDSCH receptions and PUSCH/PUCCH | Optional with capability signalling |

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| 23. NR\_FeMIMO | 23-1-2 | Inter-cell beam measurement and reporting ~~[~~(for inter-cell BM ~~[~~and mTRP~~]~~)~~]~~ | 1. Support of L1-RSRP measurement and reporting on SSB(s) with PCI(s) different from serving cell PCI  2. Support of up to K~~[=4]~~ SSBRI-RSRP ~~[~~pairs~~/beams]~~ in one report ~~[~~where ~~at least one~~ a ~~[~~pair~~/beam]~~ is associated with a PCI different from serving cell PCI can be reported~~]~~ ~~(FFS: if K is a component candidate value)~~  3. The maximum number of ~~[~~RRC-configured~~]~~ PCI(s) different from serving cell PCI for L1-RSRP measurement~~]~~ ~~(FFS: whether to split this for FR1 and FR2) (FFS: whether/how to capture different values/behaviors for periodic/aperiodic/semi-persistent L1-RSRP measurement)~~  4. The max number of SSB resources configured to measure L1-RSRP within a slot with PCI(s) same as or different from serving cell PCI ~~[~~across all CC~~]~~  [5. The max number of SSB resources configured to measure L1-RSRP with PCI(s) same as or different from serving cell PCI [across all CC]]  ~~[6. Support on that SSB(s) with PCI(s) different from serving cell PCI configured for L1 beam measurement and report are not included in SSBs with PCIs configured for L3 mobility measurement]~~  ~~[7. Supported mode inter-cell measurement: {inside SMTC, both inside and outside SMTC}]~~  ~~[8. Supported mode of measurement over overlapped SSBs: {overlapped, both overlapped and non-overlapped}]~~  ~~[9. Maximum number of overlapped SSBs in one SSB resource for L1-RSRP measurement]~~ | ~~[2-24, 2-29]~~ | Yes |  | Inter-cell beam measurement and reporting ~~[~~(for inter-cell BM ~~[~~and mTRP~~]~~)~~]~~ is not supported | per band | n/a | n/a | n/a | Component 3 candidate values: {1, 2, 3, 4, 5, 6, 7}  Component 4 candidate values: {1, 2, 4, 8}  Note: K is equal to *maxNumberNonGroupBeamReporting*  ~~[~~Note: ~~Whether~~ component 4 [and/or 5 are/is] also counted in FG16-1g/16-1g-1~~]~~ | Optional with capability signalling |

**Agreement: Introduce the following new FGs**

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| 23. NR\_FeMIMO | 23-5-1 | Unified TCI with separate DL/UL TCI update for intra- [and inter-] cell beam management | 1. Separate DL/UL TCI update with their components: (configuration mechanism, QCL rules, applicable source and target signals) 2. The maximum number of configured DL TCI states [across all CC in a band/ per BWP per CC] 3. The maximum number of configured UL TCI states [across all CC in a band/ per BWP per CC] 4. One MAC-CE activated DL TCI state per CC in a band 5. One MAC-CE activated UL TCI state per CC in a band 6. TCI state indication for update and activationa) MAC CE based TCI state indication for one active DL/UL TCI state 7. The maximum number of MAC-CE activated DL TCI states across all CC(s) in a band 8. The maximum number of MAC-CE activated UL TCI states across all CC(s) in a band | 23-1-1 | Yes |  | Unified TCI with separate DL/UL TCI update for intra- [and inter-] cell beam management is not supported | per band | n/a | n/a | n/a |  | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-5-1b | Unified TCI with separate DL/UL TCI update for intra- and inter-cell beam management with more than one MAC-CE activated separate TCI state per CC | 1. TCI state indication for update and activation b) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_1/1\_2 with DL assignment) c) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_1/1\_2 without DL assignment) 2. The minimum beam application time between PUCCH of ACK and the first slot in Y symbols per SCS 3. The maximum number of MAC-CE activated DL TCI states per CC in a band 4. The maximum number of MAC-CE activated UL TCI states per CC in a band |  | Yes |  | Unified TCI with separate DL/UL TCI update for intra- and inter-cell beam management with more than one MAC-CE activated separate TCI state per CC is not supported | per band | n/a | n/a | n/a |  | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-5-1e | TCI state pool configuration with DL/UL-TCI pool sharing for CA mode | 1. Support of reference BWP/CC configured with reference TCI state pool shared by a set of BWP/CC 2. The maximum number of configured DL TCI state pools across all BWPs and all CCs in a band 3. The maximum number of configured UL TCI state pools across all BWPs and all CCs in a band |  | Yes |  | TCI state pool configuration with DL/UL-TCI pool sharing for CA mode is not supported | per band | n/a | n/a | n/a |  | Optional with capability signalling |

**Proposal: Adopt the following changes highlighted in chromatic fonts, while keeping the yellow highlighting, if any, as shown**

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| 23. NR\_FeMIMO | 23-5-1b | Unified TCI with separate DL/UL TCI update for intra- and inter-cell beam management with more than one MAC-CE activated separate TCI state per CC | 1. TCI state indication for update and activation b) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_1/1\_2 with DL assignment) c) MAC-CE+DCI-based TCI state indication (use of DCI formats 1\_1/1\_2 without DL assignment) 2. The minimum beam application time between PUCCH of ACK and the first slot in Y symbols per SCS 3. The maximum number of MAC-CE activated DL TCI states per CC in a band 4. The maximum number of MAC-CE activated UL TCI states per CC in a band |  | Yes |  | Unified TCI with separate DL/UL TCI update for intra- and inter-cell beam management with more than one MAC-CE activated separate TCI state per CC is not supported | per band | n/a | n/a | n/a |  | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-5-1e | TCI state pool configuration with DL/UL-TCI pool sharing for CA mode | 1. Support of reference BWP/CC configured with reference TCI state pool shared by a set of BWP/CC 2. The maximum number of configured DL TCI state pools across all BWPs and all CCs in a band 3. The maximum number of configured UL TCI state pools across all BWPs and all CCs in a band |  | Yes |  | TCI state pool configuration with DL/UL-TCI pool sharing for CA mode is not supported | per band | n/a | n/a | n/a |  | Optional with capability signalling |

**Proposal: Introduce the following new FGs**

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| 23. NR\_FeMIMO | 23-5-1c | SCell BFR with unified TCI framework | 1. Support of SCell BFR with unified TCI framework |  | Yes |  |  | per band | n/a | n/a | n/a |  | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-5-1d | Per BWP DL/UL-TCI state pool configuration for CA mode | 1. Support of DL/UL TCI state pool configuration per BWP for CA mode |  | Yes |  |  | per band | n/a | n/a | n/a |  | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-5-1f | Common multi-CC DL/UL-TCI state ID update and activation | Common multi-CC DL/UL-TCI state ID update and activation |  | Yes |  |  | per band | n/a | n/a | n/a |  | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-5-1g | Beam misalignment between the DL source RS in the UL TCI state | Beam misalignment between the DL source RS in the UL TCI state to provide spatial relation indication and the PL-RS |  | Yes |  |  | per band | n/a | n/a | n/a |  | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-5-1h | Association between UL-TCI state and UL PC settings for PUCCH, PUSCH, and SRS | For PUCCH, PUSCH, and SRS, association between UL-TCI state and UL PC settings except for PL RS |  | Yes |  |  | per band | n/a | n/a | n/a |  | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-5-1i | Indication/configuration of R17 DL-TCI states for aperiodic CSI-RS, PDCCH, PDSCH and SRS | Support of indication/configuration of R17 DL TCI states for aperiodic CSI-RS, PDCCH, PDSCH (except for TRS and for CORESET #0 and the respective PDSCH reception) reusing the Rel-15/16 signaling/configuration design(s); |  | Yes |  |  | per band | n/a | n/a | n/a |  | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-5-1j | Indication/configuration of R17 UL-TCI states for SRS | Support of indication/configuration of R17 UL TCI states for SRS reusing the Rel-15/16 signaling/configuration design(s); |  | Yes |  |  | per band | n/a | n/a | n/a |  | Optional with capability signalling |
| 23. NR\_FeMIMO | 23-1-1j | Indication/configuration of R17 TCI states for CORESET #0 | Support of indication/configuration of R17 TCI states for CORESET #0 and the respective PDSCH reception reusing the Rel-15/16 signaling/configuration design(s) |  | Yes |  |  | per band | n/a | n/a | n/a |  | Optional with capability signalling |

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| 23. NR\_FeMIMO | 23-1-1c | SCell BFR with unified TCI framework | 1. Support of SCell BFR with unified TCI framework  ~~[~~2. Maximum number of CCs configured with SCell BFR with unified TCI framework [in a band with SpCell BFR~~]~~ |  | Yes |  | SCell BFR with unified TCI framework is not supported | Per band | n/a | n/a | n/a | Component 2 candidate values: {0, 1, 2, 4} | Optional with capability signalling |

[R1-2203107](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2203107.zip) Rel-17 UE features for further NR MIMO enhancements Huawei, HiSilicon

[R1-2203262](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2203262.zip) UE features for feMIMO ZTE

[R1-2203529](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2203529.zip) Discussion on UE features for further enhancements on NR-MIMO vivo

[R1-2203777](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2203777.zip) Discussion on FeMIMO UE features xiaomi

[R1-2203877](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2203877.zip) Views on UE features for Rel-17 NR FeMIMO Samsung

[R1-2203951](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2203951.zip) UE features for further enhancements on NR-MIMO OPPO

[R1-2204032](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2204032.zip) Discussion on UE features for FeMIMO Ericsson

[R1-2204140](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2204140.zip) Discussion on Rel-17 UE feature for NR FeMIMO LG Electronics

[R1-2204218](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2204218.zip) Views on Rel-17 FeMIMO UE features Apple

[R1-2204356](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2204356.zip) Discussion on Rel-17 FeMIMO UE features NTT DOCOMO, INC.

[R1-2204586](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2204586.zip) On UE features for further enhancements on NR-MIMO Nokia, Nokia Shanghai Bell

[R1-2204690](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2204690.zip) UE Features for further enhancements on NR MIMO MediaTek Inc.

[R1-2204779](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2204779.zip) UE features for NR feMIMO Intel Corporation

R1-2204849 Summary of UE features for further enhancements on NR-MIMO Moderator (AT&T)

[R1-2204998](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_109-e\Docs\R1-2204998.zip) Discussion on FeMIMO UE features Qualcomm Incorporated