**3GPP TSG RAN WG1 #105-e R1-210nnnn**

**e-Meeting, May 10th – 27th, 2021**

Source: Moderator (CATT)

Title: Moderator summary #3 on M-TRP simultaneous transmission with multiple Rx panels

Agenda Item: 8.1.2.3

Document for: Discussion and Decision

1. Background

This document summarizes company contribution on agenda 8.1.2.3, M-TRP simultaneous transmission with multiple Rx panels.

# Discussion

* 1. Beam measurement/reporting

Table 1

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| **#** | **Issue and proposals** | **Companies’ views** | **notes** |
| 1.1 | max # of beams (M) increased beyond 2     * Beam measurement reporting Option 1 * Beam measurement reporting Option 2 | Option 1: ZTE (max M = 4),  Option 2: |  |
| 1.2 | Q1: max # of pair/group (N)   * Alt1: maximum value N = {1, 2} * Alt2: maximum value N = {1, 2, 3, 4}   Q2: number of beam pairs/groups (N) reported in a single CSI-report   * Alt1: The value of N is fixed by RRC configuration * Alt2: The value of N is upper bounded by a maximum value Nmax configured by RRC, and dynamically selected/indicated by UE | Q1:   * Alt-1 (4): vivo, Spreadtrum, OPPO, Apple, * Alt-2 (19): Futurewei, Huawei, HiSilicon, InterDigital, Lenovo/MotM, ZTE, Qualcomm, SONY, Nokia/NSB, Samsung, MediaTek, AT&T, Ericsson, TCL, ETRI, Intel, DOCOMO,   Q2:   * Alt-1 (13 companies) : Futurewei, Huawei, HiSilicon, OPPO, SONY, MediaTek, LGE, Ericsson, CATT, ETRI, Intel, DOCOMO, Xiaomi, * Alt-2 (9 companies): InterDigital, vivo, ZTE, Qualcomm, Nokia/NSB, Samsung, CATT (if Alt-1 is mandately supported), TCL, |  |
| 1.3 | CMR configurations for beam measurement option 2  Q1: Two CMR resource sets or subsets, per periodic/semi-persistent CMR resource setting   * + Alt-1: set   + Alt-2: subset   Q2: SSBRI/CRI bandwidth   * Alt-1: from # of resources in the the associated set/subset * Alt-2: from total # of resources across both set/subset | Q1:   * Alt-1 (12 companies): Huawei, HiSilicon, Lenovo/MotM, Spreadtrum, ZTE, CMCC, Qualcomm, OPPO, Apple, Sony, Intel, * Alt-2 (10 companies): vivo, CATT, Nokia/NSB, Samsung, AT&T, LGE, TCL, ETRI, DOCOMO   Q2:   * Alt-1 (5 companies): Lenovo/MotM, Qualcomm, OPPO, DOCOMO * Alt-2 (1 company): Samsung, |  |
| 1.4 | UE reporting of information related to Rx panel/antenna-group   * Alt-1: UE reports panel ID / antenna-group ID or the reporting setting is associated with panel ID/antenna-group ID   + the reporting setting is associated with panel ID/ antenna-group ID * Alt-2: UE indicates if reported beams are associated to different RX spatial filters, or maximum number of supported layers corresponding to DL RS in a group, or whether two beams in a beam pair can be used for spatial multiplexing or diversity | Alt1 (2): ZTE, DOCOMO,  Alt-2 (9); vivo (same/different spatial filters), CMCC, Qualcomm, Apple (UE capability in the max number of layers per Rx beam), Samsung, Ericsson, Intel, Xiaomi, CATT |  |
| 1.5 | gNB indication of Rx panel related hypothesis   * Corresponding to issue 1.4 | Support: Intel (Alt-2) |  |
| 1.6 | Simultaneous report of beams suitable for S-TRP and M-TRP separately | Support: vivo, |  |
| 1.7 | Q1: Support L1-SINR  Q2: support interference measurement by taking into inter-beam interference within a group | Q1:   * Support (17): Huawei, HiSilicon, Lenovo/MotM, Spreadtrum, ZTE, Qualcomm, OPPO (option 1), Sony, Nokia/NSB (only with dedicated IMR), AT&T, LGE, ETRI, DOCOMO, Xiaomi, CATT * No (3): vivo, OPPO, Apple,   Q2:   * Support (10): Huawei, HiSilicon, Lenovo/MotM, ZTE, LGE, CATT, DOCOMO, Xiaomi, CATT |  |
| 1.8 | Whether to adopt additional beam measurement/reportion option   * Option 1: In a CSI-report, UE can report N>1 pair/groups and M>=1 beams per pair/group, Different beams in different pairs/groups can be received simultaneously * Option 3: UE report M(M>=1) beams in N (N>1) CSI-reports corresponding to N report setting, Different beams in different CSI-reports can be received simultaneously   + Association mechanism FFS | Option 1   * Support (5): Lenovo/MotM, OPPO, Sony, DOCOMO, * No (2): Apple, Ericsson   Option 3   * Support (8): Huawei, HiSilicon, vivo, Nokia/NSB, AT&T, CATT), * No(3): Apple, Ericsson, DOCOMO |  |
| 1.9 | New beam measurement metric,   * Alt-1: based on throughput * Alt-2: based on latency requirement and/or power window between resources within pair/group or resources being power threshold (e.g. L1-RSRP/L1-SINR) | Alt-1:  Support: Qualcomm  Concern:  Alt-2:  Support:  Concern: |  |
| 1.10 | gNB indicates (for throughput or reliability), operation mode (FDM/SDM/TDM), and corresponding beam pair selection criterion (based on sum or minimum of metrics of the two reported beams). | Support: Qualcomm  Concern: |  |
| 1.11 | Mapping of CMR subset/set to TRP  Alt-1: spec transparent  Alt-2: specified (explicit for SSB-based CMR, implicit for CSI-RS based CMR) | Alt-1:  Alt-2: Nokia/NSB |  |
| 1.12 | Latency reduction:   * Support beam reporting criteria that imposes UE to rank and report only measured CSI resources being within a certain power window or above a power threshold. | Support: Nokia/NSB  Concern: |  |
| 1.13 | Mechanism for fallback to STRP transmission, e.g.   * Alt-1: use Rel-15 group reporting (with a restriction on ‘per TRP’ with predefined TRP) * Alt-2: use Rel-15 non-group reporting (no restriction on simultaneous reception) * Alt-3: network configures the fallback reporting (based on Alt-1 or Alt-2) | Support: Nokia/NSB  Concern: |  |
| 1.14 | Study enhancement for different TDD DL/UL configuration across multiple TRPs. | Support: LGE  Concern: |  |
| 1.15 | Reuse simultaneousReceptionDiffTypeD-r16 UE capability to indicate if the UE is capable of receiving beams within a beam pair/group with different Rx spatial filters. | Support: Ericsson  Concern: |  |

* + 1. CMR configuration

It was agreed in the last meeting to down-select from two candidate options (e.g. subset vs. set) for CMR configuration of beam measurement/reporting option 2. The number of companies supportling each proposal are roughly the same. Another open issues is the bitwidth of each CRI. More companies support calculating the bitwidth of each SSBRI/CRI based on the number of resources in the corresponding CMR set/subet. Please note these two issues need to be decided in RAN1#105-e.

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| 1.3 | CMR configurations for beam measurement option 2  Q1: Two CMR resource sets or subsets, per periodic/semi-persistent CMR resource setting   * + Alt-1: set   + Alt-2: subset   Q2: SSBRI/CRI bandwidth   * Alt-1: from # of resources in the the associated set/subset * Alt-2: from total # of resources across both set/subset | Q1:   * Alt-1 (12 companies): Huawei, HiSilicon, Lenovo/MotM, Spreadtrum, ZTE, CMCC, Qualcomm, OPPO, Apple, Sony, Intel, * Alt-2 (10 companies): vivo, CATT, Nokia/NSB, Samsung, AT&T, LGE, TCL, ETRI, DOCOMO   Q2:   * Alt-1 (5 companies): Lenovo/MotM, Qualcomm, OPPO, DOCOMO * Alt-2 (1 company): Samsung, |

Offline proposal:

* The bitwidth of each SSBRI/CRI is determined based on the number of SSB/CSI-RS resources in the associated CMR resource set/subset
  + NOTE: whether “set” or “subset” is adopted will be decided in RAN1#105-e.

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* + 1. UE panel/antenna related feedback

On UE panel/antenna related feedback, two high level alternatives were discussed in the previous meeting. Alt-1 is supported by 2 companies, and alt-2 is supported by 9 companies. One company also supports gNB indication/configuration of UE hypothesis related to Alt-2 (e.g. whether reported beams associated to different Rx spatial filters, maximum number of supported layers, whether two beams can be used for sptial multiplexing or diversity).

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| 1.4 | UE reporting of information related to Rx panel/antenna-group   * Alt-1: UE reports panel ID / antenna-group ID or the reporting setting is associated with panel ID/antenna-group ID   + the reporting setting is associated with panel ID/ antenna-group ID * Alt-2: UE indicates if reported beams are associated to different RX spatial filters, or maximum number of supported layers corresponding to DL RS in a group, or whether two beams in a beam pair can be used for spatial multiplexing or diversity | Alt1 (2 companies): ZTE, DOCOMO,  Alt-2 (9 companies); vivo (same/different spatial filters), CMCC, Qualcomm, Apple (UE capability in the max number of layers per Rx beam), Samsung, Ericsson, Intel, Xiaomi, CATT |

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* + 1. L1-SINR and interference measurement

L1-SINR measurement is supported by 17 companies, while 3 companies have concerns. Among the 17 supporting companies, one company only supports it for beam measurement option 1 (not agreed yet), and two companies only support if dedicated IMR is configured. 10 companies support to measure intra-group cross-beam interference in L1-SINR measurement.

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| 1.7 | Q1: Support L1-SINR report  Q2: support interference measurement by taking into inter-beam interference within a group | Q1:   * Support (17): Huawei, HiSilicon, Lenovo/MotM, Spreadtrum, ZTE, Qualcomm, OPPO (option 1), Sony, Nokia/NSB (only with dedicated IMR), AT&T, LGE, ETRI, DOCOMO, Xiaomi, CATT * No (3): vivo, OPPO, Apple,   Q2:   * Support (10): Huawei, HiSilicon, Lenovo/MotM, ZTE, LGE, CATT, DOCOMO, Xiaomi, CATT |

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* + 1. Value of N (number of beam groups)

It was agreed to decide on the maximum value of N in a single CSI-report (2 vs. 4) in RAN1#105-e. 19 companies support N = 4, and 4 companies support N = 2.

Another issue is the number of actual beam groups (N) in a single CSI-report, e.g. whether fixed by RRC configuration or dynamically selected by UE.

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| 1.2 | Q1: max # of pair/group (N)   * Alt1: maximum value N = {1, 2} * Alt2: maximum value N = {1, 2, 3, 4}   Q2: number of beam pairs/groups (N) reported in a single CSI-report   * Alt1: The value of N is fixed by RRC configuration * Alt2: The value of N is upper bounded by a maximum value Nmax configured by RRC, and dynamically selected/indicated by UE | Q1:   * Alt-1 (4 companies): vivo, Spreadtrum, OPPO, Apple, * Alt-2 (19 companies): Futurewei, Huawei, HiSilicon, InterDigital, Lenovo/MotM, ZTE, Qualcomm, SONY, Nokia/NSB, Samsung, MediaTek, AT&T, Ericsson, TCL, ETRI, Intel, DOCOMO,   Q2:   * Alt-1 (13 companies) : Futurewei, Huawei, HiSilicon, OPPO, SONY, MediaTek, LGE, Ericsson, CATT, ETRI, Intel, DOCOMO, Xiaomi, * Alt-2 (9 companies): InterDigital, vivo, ZTE, Qualcomm, Nokia/NSB, Samsung, CATT (if Alt-1 is mandatorily supported), TCL, |

Offline proposal:

* For beam measurement/reporting option 2, the maximum number of beam groups (N) in a single CSI-report is a UE capability and may take value from Nmax = {1,2,3,4} in Rel.17.

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| Company | Technical views |
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* + 1. Others

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| 1.1 | max # of beams (M) increased beyond 2     * Beam measurement reporting Option 1 * Beam measurement reporting Option 2 | Option 1: ZTE (max M = 4),  Option 2: |
| 1.5 | gNB indication of Rx panel related hypothesis   * Corresponding to issue 1.4 | Support: Intel (Alt-2) |
| 1.6 | Simultaneous report of beams suitable for S-TRP and M-TRP separately | Support: vivo, |
| 1.8 | Whether to adopt additional beam measurement/reportion option   * Option 1: In a CSI-report, UE can report N>1 pair/groups and M>=1 beams per pair/group, Different beams in different pairs/groups can be received simultaneously * Option 3: UE report M(M>=1) beams in N (N>1) CSI-reports corresponding to N report setting, Different beams in different CSI-reports can be received simultaneously   + Association mechanism FFS | Option 1   * Support (5): Lenovo/MotM, OPPO, Sony, DOCOMO, * No (2): Apple, Ericsson   Option 3   * Support (8): Huawei, HiSilicon, vivo, Nokia/NSB, AT&T, CATT), * No(3): Apple, Ericsson, DOCOMO |
| 1.9 | New beam measurement metric,   * Alt-1: based on throughput * Alt-2: based on latency requirement and/or power window between resources within pair/group or resources being power threshold (e.g. L1-RSRP/L1-SINR) | Alt-1:  Support: Qualcomm  Concern:  Alt-2:  Support:  Concern: |
| 1.10 | gNB indicates (for throughput or reliability), operation mode (FDM/SDM/TDM), and corresponding beam pair selection criterion (based on sum or minimum of metrics of the two reported beams). | Support: Qualcomm  Concern: |
| 1.11 | Mapping of CMR subset/set to TRP  Alt-1: spec transparent  Alt-2: specified (explicit for SSB-based CMR, implicit for CSI-RS based CMR) | Alt-1:  Alt-2: Nokia/NSB |
| 1.12 | Latency reduction:   * Support beam reporting criteria that imposes UE to rank and report only measured CSI resources being within a certain power window or above a power threshold. | Support: Nokia/NSB  Concern: |
| 1.13 | Mechanism for fallback to STRP transmission, e.g.   * Alt-1: use Rel-15 group reporting (with a restriction on ‘per TRP’ with predefined TRP) * Alt-2: use Rel-15 non-group reporting (no restriction on simultaneous reception) * Alt-3: network configures the fallback reporting (based on Alt-1 or Alt-2) | Support: Nokia/NSB  Concern: |
| 1.14 | Study enhancement for different TDD DL/UL configuration across multiple TRPs. | Support: LGE  Concern: |
| 1.15 | Reuse simultaneousReceptionDiffTypeD-r16 UE capability to indicate if the UE is capable of receiving beams within a beam pair/group with different Rx spatial filters. | Support: Ericsson  Concern: |

Companies are welcome to provide their views on other issues in Table I that are not covered in section 2.1.1 – 2.1.4.

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| Company | Technical views |
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* 1. M-TRP Beam failure recovery

**Table II**

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| **#** | **Issue** | **Companies’ views** | **notes** |
| 2.0  BFR configuration | Configuration of cell-specific BFR and TRP-specific BFR on the same cell | * Support (12): Lenovo/MotM, CMCC, Sony, Nokia/NSB (at least SpCell), Samsung (SCell triggered if both TRP fail), MediaTek (CBRA-based cell-specific), LGE, APT, TCL, Xiaomi (SpCell only) * No (4): Qualcomm, Intel, DOCOMO, CATT * Postpone: vivo, APT, |  |
| 2.1  BFD-RS | # of BFD-RS resources per set   * Alt1: max value is 2 * Alt2: max value is a UE capability, including possible candidate value of 1 | * Alt1 (7): Huawei, HiSilicon, InterDigital, Nokia/NSB, APT, Convida * Alt2 (9): vivo, Spreadtrum, Qualcomm, Apple, LGE, TCL, ETRI, DOCOMO, CATT |  |
| 2.2 BFD-RS | Clarify whether/how to define BFD-RS selection rule for implicit BFD-RS when total number of QCL-typeD RS of all CORESETs exceed UE capability | Support: LGE  Concern: |  |
| 2.3  BFD-RS | Explicit vs. implicit BFD-RS  Q1: Explicit configuration  Q2: Implicit configuration of BFD-RS set k (k=0,1) for M-DCI   * Based on TCI of CORESETs with CORESETPoolIndex = k   Q3: Implicit configuration BFD-RS set k for S-DCI   * Based on TCI of CORESETs with CORESETPoolIndex = k * Extend CORESETPoolIndex to S-DCI (for BFD-RS set generation) | * Q1 (15): vivo (both), Spreadtrum, ZTE, Qualcomm, Fujitsu, Sony, Samsung, MediaTek, AT&T, LGE, Ericsson, APT, Convida, ETRI, DOCOMO. * Q2 (21): vivo, ZTE, Qualcomm, OPPO (CORESETPoolIndex), Apple (CORESETPoolIndex), Sony, NEC, Nokia/NSB, Samsung, MediaTek, AT&T, LGE, Ericsson, APT, Convida, ETRI, Intel, DOCOMO, Xiaomi, CATT * Q3 (11): vivo (when one TRP fail in CC1 and no TRP fail in CC2, FFS other cases), Sony, NEC (both S/M), Nokia (and SFN/non-SFN PDCCH enhancement), Samsung, MediaTek (extend CORESETPoolIndex), AT&T, LGE, Convida, ETRI, Intel (extend CORESETPoolIndex to SDCI), CATT |  |
| 2.4  BFD-RS | Introduce MAC-CE for updating explicit BFD-RS set | * Support: ZTE, CATT (if implicit BFD-RS is not supported) |  |
| 2.5  BFD-RS | Implicit BFD-RS generation, when a CORESET is configured with two TCI states   * Alt1: based on both TCI states | * Support: Ericsson * Postpone: Convida |  |
| 2.6  NBI-RS | Association between BFD-RS set k and NBI-RS set j   * Alt-1: 1-to-1, fixed in spec * Alt-2: 1-to-1, configurable * Alt-3: 1-to-1, leave it to RAN2 | Alt-1 (7): CMCC, Apple, ETRI, CATT, Intel, Huawei, HiSilicon  Alt-2 (4): Qualcomm, Fujitsu, Nokia/NSB  Alt-3: |  |
| 2.7  NBI-RS | NBI RS sets are disjoint | Support: Convida  Concern: |  |
| 2.8  NBI-RS | NBI-RS configuration is optional   * If not configured, UE supports triggering of A-CSI to obtain new beams | Support: vivo  Concern: |  |
| 2.9  PUCCH-SR resource | Whether/how to associate PUCCH-SR resource and SR configuration   * Alt-1: 2 PUCCH-SR are associated to 1 SR configuration * Alt-2: 2 PUCCH-SR are associated to 2 separate SR configuration * Alt-3: leave to RAN2 (no RAN1 impact) | Alt-1: Qualcomm, DOCOMO, CATT  Alt-2: OPPO  Alt-3: CATT |  |
| 2.10  PUCCH-SR resource | PUCCH-SR resource selection rule for LRR feedback   * Alt-1: PUCCH-SR resource associated with other/non-failed BFD-RS set, association details FFS * Alt-2: PUCCH-SR resource associated with failed BFD-RS set, association details FFS * Alt-3: Leave it up to UE implementation | Alt-1 (11): Huawei, HiSilicon, vivo, Lenovo/MotM (1 TRP fail, or when 1 SR configuration has 2 PUCCH-SR), Sony, NEC (when SpCell has two TRP), Samsung (if PUCCH-SR has 1 filter), Ericsson, ETRI, DOCOMO,  Alt-2 (15): InterDigital, vivo, Lenovo/MotM (1 TRP fail), ZTE, Qualcomm, OPPO, Fujitsu, Sony, Apple (if each PUCCH-SR belongs to one SR configuration), Nokia/NSB, ASUSTek, Xiaomi, CATT  Alt-3 (9): Lenovo/MotM (when neither/both TRP fail in the PUCCH-Cell, or when 2 SR configurations are configured each with 1 PUCCH-SR), Spreadtrum, Apple (if both PUCCH-SR belongs to one SR configuration), NEC (when SpCell is configured with one TRP), Samsung (if PUCCH-SR has two filters), LGE, APT, Convida, Intel |  |
| 2.11  PUCCH-SR resource | Whether PUCCH-SR resource can have 1 or 2 activated spatial filters  Alt-1: Only 1  Alt-2: up to 2; diversity (e.g. AI 8.1.2.1) when 2 spaial filters are activated  Alt-3: up to 2; filter selection when 2 spatial filters are activated  Alt-4: up to 2; transmission method undefined when 2 spatial filters are activated | Alt-1: Spreadtrum, Intel,  Alt-2: vivo,  Alt-3: Qualcomm (select filter associated with failed TRP)  Alt-4: Apple, LGE, APT, ETRI, CATT |  |
| 2.12  PUCCH-SR resource | Whether to reuse PUCCH-SR of SCell BFR for MTRP BFR   * Alt-1: leave to gNB implementation * Alt-2: Yes * Alt-3: No | Alt-1:  Alt-2: CMCC  Alt-3: No |  |
| 2.13  MAC-CE | Q: One or two MAC-CE for TRP-specific BFR   * Alt-1: one MAC-CE * Alt-2: two MAC-CE * Alt -3: leave it to RAN2 | Alt-1: Lenovo/MotM, CATT, MediaTek, LGE, TCL, Intel,  Alt-2: ZTE, Ericsson (?)  Alt-3: |  |
| 2.14  MAC-CE | Indication of failed TRP in MAC-CE (NOTE: this question may depend on the outcome of 2.13)   * Alt-1: indication of failed BFD-RS set * Alt-2: indication of CORESETPoolIndex | Alt-1: Huawei, HiSilicon, CATT, vivo, Nokia/NSB, LGE  Alt2: OPPO, Sony, |  |
| 2.15  MAC-CE | Indication of new beam in MAC-CE   * Alt-1: new beam index (if found) for only 1 failed TRP, irrespective of 1 or 2 TRP failure * Alt-2: new beam index (if found) for each failed TRP | Alt1: DOCOMO,  Alt2: Huawei, HiSilicon, CATT, DOCOMO |  |
| 2.16  MAC-CE | Q: whether to support BFRQ MAC-CE for SpCell with normal PUSCH   * NOTE: In Rel.16 it is only supported in msg3 | Support: MediaTek  Concern: |  |
| 2.17  Beam update | Q: UE assumption of DL QCL-typeD and UL filter/power control after receiving gNB response  Q1: If a single TRP fails   * Failed TRP update by new beam (if reported)   Q2: If both TRPs fail   * Each failed TRP updated by its corresponding new beam (if reported)   Q3: Applicable channel   * at least PDCCH, * FFS: others * FFS: association of PUCCH with TRP (if PUCCH beam update is supported)   Q4: deactivation of CORESETs for a TRP, if no new beam is found | Q1: vivo, Qualcomm, CATT  Q2: vivo, Qualcomm, CATT  Q3:   * PDCCH: Sony, OPPO, CATT, vivo, ZTE, Qualcomm, MediaTek, ETRI, * PDSCH: vivo (M-DCI), Apple * PUCCH: Support (ZTE, Qualcomm, Sony, ETRI, DOCOMO, Apple, CATT), No (OPPO) * All channels: Apple   Q4:  Support: vivo, ZTE  Concern: |  |
| 2.18  RACH | Q1: CBRA based RACH  Q2: CFRA-based RACH | Q1:  Support: ZTE/Intel/DOCOMO  Concern: OPPO  Q2:  Support: OPPO  Concern: |  |
| 2.19  other | New BFRR mechanism  a MAC CE activation command to update the TCI states for the CORESET(s) related to the TRP/BFD-RS set in beam failure.  a MAC CE deactivation command to de-activate the failed TRP so that to achieve the switch of transmission hypothesis from MTRP to STRP.  a PDCCH to trigger a beam measurement and reporting procedure for the failed TRP. | Support: vivo  Concern: |  |
| 2.20  other | Implicit BFD-RS is only supported if Rel.17 TCI framework supports M >1 | Support: Futurewei  Concern: |  |
| 2.21  Other | Prioitize TRP1 of PCell, if beam failure is detected on both TRP | Support: InterDigital  Concern: |  |
| 2.22  Other | Fallback to single-TRP transmission   * Conditions FFS (e.g. 1 TRP fail without new beam found, or 2 TRPs fail and new beam found on 1 TRP) | Support: vivo  Concern: |  |
| 2.23  other | LRR has higher priority than normal SR   * FFS: prioritization between LRR for TRP-specific BFR and LRR for SCell BFR | Support: Lenovo/MotM  Concern: |  |
| 2.24  other | Study how to avoid transmission of PUSCH carrying MAC-CE to failed TRP | Support: Lenovo/MotM  Concern: |  |
| 2.25  other | For mDCI mTRP, the implicit BFD RSs associated with a *CORESETPoolIndex* can be the QCL-TypeD RSs in up to X TCI states for CORESETs sharing the same *CORESETPoolIndex*.   * X can be determined in spec or via UE capability. | Support: Qualcomm  Concern: |  |
| 2.26  other | support per-TRP BFD-RS configurations for both intra-cell and inter-cell multi-DCI based multi-TRP operation. | Support: Ericsson  Concern: |  |
| 2.27  other | M-DCI in TRP-specific BFR, if one TRP is declared beam failure and if the time offset between the reception of the DL DCI and the corresponding PDSCH is less than a threshold, UE keeps one default Rx beam for receiving potential PDSCH transmitted from non-failed TRP | Support: ASUSTek  Concern: |  |
| 2.28  other | If the UE detects beam failure in the first BFD-RS set, it shall try to  find a new candidate beam from the first NBI-RS set with L1-RSRP above a threshold, if any. If the UE detects beam failure in the second BFD-RS set, it shall try to find a new candidate beam from the second NBI-RS set with L1-RSRP above a threshold, if any. | Support: Convida  Concern: |  |
| 2.29  other | * For multi-TRP BFR, upon request from higher layers to evaluate candidate beams in a first NBI-RS set, the UE indicates to higher layers whether there is at least one periodic CSI-RS configuration index and/or SS/PBCH block index from the first NBI-RS set with corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, and provides the periodic CSI-RS configuration indexes and/or SS/PBCH block indexes from the first NBI-RS set and the corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, if any. * For multi-TRP BFR, upon request from higher layers to evaluate candidate beams in a second NBI-RS set, the UE indicates to higher layers whether there is at least one periodic CSI-RS configuration index and/or SS/PBCH block index from the second NBI-RS set with corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, and provides the periodic CSI-RS configuration indexes and/or SS/PBCH block indexes from the second NBI-RS set and the corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, if any. | Support: Convida  Concern: |  |

* + 1. Simultaneous configuration of cell-specific and TRP-specifc BFR on the same cell

In the last meeting the following proposal was discussed.

**Offline Proposal (RAN1#104b-e)**:

* FFS: whether cell-specific and TRP-specific BFR can be configured in the same CC.

Company inputs in RAN1#105-e are summarized in the following table.

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| 2.0  BFR configuration | Configuration of cell-specific BFR and TRP-specific BFR on the same cell | * Support (12): Lenovo/MotM, CMCC, Sony, Nokia/NSB (at least SpCell), Samsung (SCell triggered if both TRP fail), MediaTek (CBRA-based cell-specific), LGE, APT, TCL, Xiaomi (SpCell only) * No (4): Qualcomm, Intel, DOCOMO, CATT * Postpone: vivo, APT, |

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| Company | Technical views |
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* + 1. BFD-RS number

It was agreed in the last meeting to down select from two options on the number of BFD-RS resources per BFD-RS set in RAN1#105-e. It appears the number of supporting companies are close, with slightly more companies supporting to introduce a UE capability rather than reusing a fixed value (2) in Rel.16.

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| 2.1  BFD-RS | # of BFD-RS resources per set   * Alt1: max value is 2 * Alt2: max value is a UE capability, including possible candidate value of 1 | * Alt1 (7): Huawei, HiSilicon, InterDigital, Nokia/NSB, APT, Convida * Alt2 (9): vivo, Spreadtrum, Qualcomm, Apple, LGE, TCL, ETRI, DOCOMO, CATT |

Offline proposal:

* Introduce a UE capability on the maximum number of BFD-RS resources per set, which includes possible candidate value of 1.

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| Company | Technical views |
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It was agreed in the last meeting that the total number of BFD-RS resources in a DL BWP is a UE capability. One company proposes to clarify UE behavior when the total number of QCL-typeD RS of all CORESETs exceeds UE capability. Note this issue assumes implicit BFD-RS determination will be adopted in Rel.17.

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| 2.2 BFD-RS | Clarify whether/how to define BFD-RS selection rule for implicit BFD-RS when total number of QCL-typeD RS of all CORESETs exceed UE capability | Support: LGE  Concern: |

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| Company | Technical views |
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* + 1. BFD-RS set determination

It was agreed in RAN1#104-e to support both M-DCI and S-DCI (with lower priority) in Rel.17, without precluding a unified framework. It has also been agreed that at least one of explicit and implicit BFD-RS set determination is to be adopted. Company inputs are summarized below.

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| 2.3  BFD-RS | Explicit vs. implicit BFD-RS  Q1: Explicit configuration  Q2: Implicit configuration of BFD-RS set k (k=0,1) for M-DCI   * Based on TCI of CORESETs with CORESETPoolIndex = k   Q3: Implicit configuration BFD-RS set k for S-DCI   * Based on TCI of CORESETs with CORESETPoolIndex = k * Extend CORESETPoolIndex to S-DCI (for BFD-RS set generation) | * Q1 (15): vivo (both), Spreadtrum, ZTE, Qualcomm, Fujitsu, Sony, Samsung, MediaTek, AT&T, LGE, Ericsson, APT, Convida, ETRI, DOCOMO. * Q2 (21): vivo, ZTE, Qualcomm, OPPO (CORESETPoolIndex), Apple (CORESETPoolIndex), Sony, NEC, Nokia/NSB, Samsung, MediaTek, AT&T, LGE, Ericsson, APT, Convida, ETRI, Intel, DOCOMO, Xiaomi, CATT * Q3 (11): vivo (when one TRP fail in CC1 and no TRP fail in CC2, FFS other cases), Sony, NEC (both S/M), Nokia (and SFN/non-SFN PDCCH enhancement), Samsung, MediaTek (extend CORESETPoolIndex), AT&T, LGE, Convida, ETRI, Intel (extend CORESETPoolIndex to SDCI), CATT |

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| Company | Technical views |
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For explicit BFD-RS (if supported), two companies propose to introduce MAC-CE for dynamically updating explicit BFD-RS sets. The motivation is to allow faster update of RRC configured BFD-RS set.

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| 2.4  BFD-RS | Introduce MAC-CE for updating explicit BFD-RS set | * Support: ZTE, CATT (if implicit BFD-RS is not supported) |

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| Company | Technical views |
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For a CORESET with two activated TCI states (e.g. Rel.17 PDCCH enhancement), at least one company proposes to include both TCI states in implicit BFD-RS determination. An offline proposal was discussed in the last meeting but no conclusion was reached.

**Offline Proposal (RAN1#104b-e):**

* For a CORESET associated with more than 1 activated TCI states
  + For implicit BFD-RS set determination, BFD-RS set associated with this CORESET is based on QCL-typeD source RS of all activated TCI states
  + FFS: BLER determination based on two TCI states, e.g. whether separate BLER are independently derived from each TCI state, or a common BLER is derived from all TCI states, or leave to RAN4

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| 2.5  BFD-RS | Implicit BFD-RS generation, when a CORESET is configured with two TCI states   * Alt1: based on both TCI states | * Support: Ericsson * Postpone: Convida |

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| Company | Technical views |
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* + 1. NBI-RS set

It has been agreed there is a 1-to-1 association between BFD-RS set and NBI-RS set. The following proposal has been discussed in RAN1#104b-e.

Offline Proposal (RAN1#104-e)

* On the 1-to-1 association between BFD-RS sets and NBI-RS sets, support the following association
  + Alt-1: First BFD-RS set associated with first NBI-RS set, and second to the second (NOTE: how to capture this can be up to RAN2)

Company views in this meeting on their association are summarized below. The FL proposes to continue using the offline proposal in RAN1#104b-e as a starting point for discussion.

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| 2.6  NBI-RS | Association between BFD-RS set k and NBI-RS set j   * Alt-1: 1-to-1, fixed in spec * Alt-2: 1-to-1, configurable * Alt-3: 1-to-1, leave it to RAN2 | Alt-1 (7): CMCC, Apple, ETRI, CATT, Intel, Huawei, HiSilicon  Alt-2 (4): Qualcomm, Fujitsu, Nokia/NSB  Alt-3: |

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| Company | Technical views |
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It was discussed in the previous meeting whether two NBI-RS resource sets should be disjoint, but no concusion was reached. FL proposes to clarify this issue.

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| 2.7  NBI-RS | NBI RS sets are disjoint | Support: Convida  Concern: |

Offline Proposal:

* When two NBI-RS sets are configured , set k and j are disjoint (k, j = 0, 1)
  + This applies to at least SCell. FFS for SpCell (e.g. whether NBI-RS set associated with TRP associated with CORESET #0 may include NBI-RS associated with the other TRP)

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| Company | Technical views |
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It was agreed in previous meetings that “For M-TRP BFR, support 1-to-1 association between each BFD-RS set and an NBI-RS set”, therefore the number of BFD-RS sets and NBI-RS sets can be the same in one CC. One company proposes to allow configuration of NBI-RS to be optional, e.g. only BFD-RS sets are configured in a CC.

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| 2.8  NBI-RS | NBI-RS configuration is optional   * If not configured, UE supports triggering of A-CSI to obtain new beams | Support: vivo  Concern: |

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| Company | Technical views |
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* + 1. PUCCH-SR

For the case where two PUCCH-SR resources are configured, it was agreed in the previous meeting to discuss UE behavior in terms of PUCCH-SR resource selection for LRR transmission, and down-select from the following three alternatives in RAN1#105-e. One company suggests this issue should be discussed together with the association between PUCCH-SR and SR configuration.

***Agreement (RAN1#104b-e)***

*For the TRP specific BFR, for a UE configured with two PUCCH-SR resources in a cell group when beam failure is detected in a one or more CCs in one or more of BFD-RS sets configured in one or more of CCs,*

* *Down select one of the following PUCCH-SR resource selection rules when SR is triggered (or their combinations) for the study, without precluding other alternatives, in RAN1#105-e*
  + *Alt-1: PUCCH-SR resource associated with other/non-failed BFD-RS set, association details FFS*
  + *Alt-2: PUCCH-SR resource associated with failed BFD-RS set, association details FFS*
  + *Alt-3: Leave it up to UE implementation*
* *Note: PUCCH-SR resource is PUCCH resource carrying SR*
* *FFS: Whether two PUCCH-SR resources are under the same or different SR resource configuration or SR configuration (eventual decision may or may not happen in RAN1)*

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| 2.9  PUCCH-SR resource | Whether/how to associate PUCCH-SR resource and SR configuration   * Alt-1: 2 PUCCH-SR are associated to 1 SR configuration * Alt-2: 2 PUCCH-SR are associated to 2 separate SR configuration * Alt-3: leave to RAN2 (no RAN1 impact) | Alt-1: Qualcomm, DOCOMO, CATT  Alt-2: OPPO  Alt-3: CATT |
| 2.10  PUCCH-SR resource | PUCCH-SR resource selection rule for LRR feedback   * Alt-1: PUCCH-SR resource associated with other/non-failed BFD-RS set, association details FFS * Alt-2: PUCCH-SR resource associated with failed BFD-RS set, association details FFS * Alt-3: Leave it up to UE implementation | Alt-1 (11): Huawei, HiSilicon, vivo, Lenovo/MotM (1 TRP fail, or when 1 SR configuration has 2 PUCCH-SR), Sony, NEC (when SpCell has two TRP), Samsung (if PUCCH-SR has 1 filter), Ericsson, ETRI, DOCOMO,  Alt-2 (15): InterDigital, vivo, Lenovo/MotM (1 TRP fail), ZTE, Qualcomm, OPPO, Fujitsu, Sony, Apple (if each PUCCH-SR belongs to one SR configuration), Nokia/NSB, ASUSTek, Xiaomi, CATT  Alt-3 (9): Lenovo/MotM (when neither/both TRP fail in the PUCCH-Cell, or when 2 SR configurations are configured each with 1 PUCCH-SR), Spreadtrum, Apple (if both PUCCH-SR belongs to one SR configuration), NEC (when SpCell is configured with one TRP), Samsung (if PUCCH-SR has two filters), LGE, APT, Convida, Intel |

Companies are invited to share their views on these two issues.

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| Company | Technical views |
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In Rel.16, a PUCCH resource can have 1 activated UL spatial relation info at any time. With Rel.17 PUCCH enhancement for M-TRP, it is possible that a PUCCH resource can have more than 1 activated UL spatial relation info. Several companies discussed whether Rel.17 PUCCH-SR for M-TRP BFR should be allowed to have more than 1 activated UL spatial relation info, and if so, transmission scheme. Companies are invited to share more views below.

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| 2.11  PUCCH-SR resource | Whether PUCCH-SR resource can have 1 or 2 activated spatial filters  Alt-1: Only 1  Alt-2: up to 2; diversity (e.g. AI 8.1.2.1) when 2 spaial filters are activated  Alt-3: up to 2; filter selection when 2 spatial filters are activated  Alt-4: up to 2; transmission method undefined when 2 spatial filters are activated | Alt-1: Spreadtrum, Intel,  Alt-2: vivo,  Alt-3: Qualcomm (select filter associated with failed TRP)  Alt-4: Apple, LGE, APT, ETRI, CATT |

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| Company | Technical views |
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Another issue is whether reusing PUCCH-SR for SCell BFR (if configured) for TRP-specific BFR should be supported. Companies are invited to provide their views.

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| 2.12  PUCCH-SR resource | Whether to reuse PUCCH-SR of SCell BFR for MTRP BFR   * Alt-1: leave to gNB implementation * Alt-2: Yes * Alt-3: No | Alt-1:  Alt-2: CMCC  Alt-3: |

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| Company | views |
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* + 1. BFRA MAC-CE content

The following offline proposal was discussed in RAN1#104b-e but was not agreed. There are basically two issues, e.g. whether 1 or 2 MAC-CEs are used for BFRQ reports, and contents of the MAC-CE. The second issue depends on the outcome of the first.

***Offline Proposal (RAN1#104b-e)***

* *A single MAC-CE is used for BFRQ report for all TRPs in all CCs in a cell group*
* *The MAC-CE carries information of failed TRP identifiers, e.g.* 
  + *Alt-1: indices of BFD-RS set where beam failure is detected,*
  + *Alt-2: implicitly through new beam index, if found, else explicitly through BFD-RS set index*
  + *other alternatives are not precluded*
* *For each failed TRP for a CC, BFRQ carries information whether a new candidate beam is found, and new beam index (if found).*

Company views on MAC-CE design/contents in this meeting are summarized below.

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| 2.13  MAC-CE | Q: One or two MAC-CE for TRP-specific BFR   * Alt-1: one MAC-CE * Alt-2: two MAC-CE * Alt -3: leave it to RAN2 | Alt-1: Lenovo/MotM, CATT, MediaTek, LGE, TCL, Intel,  Alt-2: ZTE, Ericsson (?)  Alt-3: |
| 2.14  MAC-CE | Indication of failed TRP in MAC-CE (NOTE: this question may depend on the outcome of 2.13)   * Alt-1: indication of failed BFD-RS set * Alt-2: indication of CORESETPoolIndex | Alt-1: Huawei, HiSilicon, CATT, vivo, Nokia/NSB, LGE  Alt2: OPPO, Sony, |
| 2.15  MAC-CE | Indication of new beam in MAC-CE   * Alt-1: new beam index (if found) for only 1 failed TRP, irrespective of 1 or 2 TRP failure * Alt-2: new beam index (if found) for each failed TRP | Alt1: DOCOMO,  Alt2: Huawei, HiSilicon, CATT, DOCOMO |

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| Company | Technical views |
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It is also proposed to support BFRA MAC-CE transmission for SpCell with normal PUSCH. Companies are invited to share their views.

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| 2.16  MAC-CE | Q: whether to support BFRQ MAC-CE for SpCell with normal PUSCH   * NOTE: In Rel.16 it is only supported in msg3 | Support: MediaTek  Concern: |

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| Company | Technical views |
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* + 1. UE assumption after BFR response

The following offline proposal was discussed in RAN1#104b-e.

*Offline proposal (RAN1#104-e) : After receiving BFR response*

* *For each failed TRP, the DL QCL-typeD assumption of all CORESETs associated with that TRP with 1 activated TCI state is updated by the RS associated with the latest reported new candidate beam (if found when NBI-RS set is configured).*
  + *FFS: How to associate CORESET(s) with each TRP*
  + *FFS: timeline for the new beam updte after receiving BFR response*
* *FFS: Update of QCL-type D assumption UL spatial filter/power control assumption for PUCCH, and other channels/RSs.*
* *The above applies at least to SCell; FFS SpCell*

Company views in RAN1#105-e are summarized below.

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| 2.17  Beam update | Q: UE assumption of DL QCL-typeD and UL filter/power control after receiving gNB response  Q1: If a single TRP fails   * Failed TRP update by new beam (if reported)   Q2: If both TRPs fail   * Each failed TRP updated by its corresponding new beam (if reported)   Q3: Applicable channel   * at least PDCCH, * FFS: others * FFS: association of PUCCH with TRP (if PUCCH beam update is supported)   Q4: deactivation of CORESETs for a TRP, if no new beam is found | Q1: vivo, Qualcomm, CATT  Q2: vivo, Qualcomm, CATT  Q3:   * PDCCH: Sony, OPPO, CATT, vivo, ZTE, Qualcomm, MediaTek, ETRI, * PDSCH: vivo (M-DCI), Apple * PUCCH: Support (ZTE, Qualcomm, Sony, ETRI, DOCOMO, Apple, CATT), No (OPPO) * All channels: Apple   Q4:  Support: vivo, ZTE  Concern: |

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| Company | Technical views |
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* + 1. RACH-based fallback

The following offline proposal was discussed in RAN1#104b-e without conclusion.

*Offline Proposal (RAN1#104-e): CBRA-based transmission can be triggered on a SpCell for per-TRP BFR as least in the following scenarios*

* *Scenario 1: When beam failure is detected on all BFD-RS sets on the SpCell*
* *FFS: other scenarios*
  + *Scenario 2: at least one TRP fails on SpCell*
  + *Scenario 3: at least one pre-defined TRP fails on SpCell*
  + *Scenario 4: at least one TRP fails and no PUCCH-SR is configured, and no UL grant is available*
  + *Scenario 5: If MAC-CE based reporting does not work (details FFS)*
  + *Scenario 6: When no PUCCH-SR is configured*
* *NOTE: It is RAN1’s understanding that RAN1 decision does not preclude RAN2 from studying other scenarios.*

Company inputs in this meeting is summarized below.

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| 2.18  RACH | Q1: CBRA based RACH  Q2: CFRA-based RACH | Q1:  Support: ZTE/Intel/DOCOMO  Concern: OPPO  Q2:  Support: OPPO |

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| Company | Technical views |
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* + 1. Others

For issues in Table II (section 2.2) that are not covered in the above sections, companies are invited to share their views.

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| 2.19  other | New BFRR mechanism  a MAC CE activation command to update the TCI states for the CORESET(s) related to the TRP/BFD-RS set in beam failure.  a MAC CE deactivation command to de-activate the failed TRP so that to achieve the switch of transmission hypothesis from MTRP to STRP.  a PDCCH to trigger a beam measurement and reporting procedure for the failed TRP. | Support: vivo  Concern: |
| 2.20  other | Implicit BFD-RS is only supported if Rel.17 TCI framework supports M >1 | Support: Futurewei  Concern: |
| 2.21  Other | Prioitize TRP1 of PCell, if beam failure is detected on both TRP | Support: InterDigital  Concern: |
| 2.22  Other | Fallback to single-TRP transmission   * Conditions FFS (e.g. 1 TRP fail without new beam found, or 2 TRPs fail and new beam found on 1 TRP) | Support: vivo  Concern: |
| 2.23  other | LRR has higher priority than normal SR   * FFS: prioritization between LRR for TRP-specific BFR and LRR for SCell BFR | Support: Lenovo/MotM  Concern: |
| 2.24  other | Study how to avoid transmission of PUSCH carrying MAC-CE to failed TRP | Support: Lenovo/MotM  Concern: |
| 2.25  other | For mDCI mTRP, the implicit BFD RSs associated with a *CORESETPoolIndex* can be the QCL-TypeD RSs in up to X TCI states for CORESETs sharing the same *CORESETPoolIndex*.   * X can be determined in spec or via UE capability. | Support: Qualcomm  Concern: |
| 2.26  other | support per-TRP BFD-RS configurations for both intra-cell and inter-cell multi-DCI based multi-TRP operation. | Support: Ericsson  Concern: |
| 2.27  other | M-DCI in TRP-specific BFR, if one TRP is declared beam failure and if the time offset between the reception of the DL DCI and the corresponding PDSCH is less than a threshold, UE keeps one default Rx beam for receiving potential PDSCH transmitted from non-failed TRP | Support: ASUSTek  Concern: |
| 2.28  other | If the UE detects beam failure in the first BFD-RS set, it shall try to  find a new candidate beam from the first NBI-RS set with L1-RSRP above a threshold, if any. If the UE detects beam failure in the second BFD-RS set, it shall try to find a new candidate beam from the second NBI-RS set with L1-RSRP above a threshold, if any. | Support: Convida  Concern: |
| 2.29  other | * For multi-TRP BFR, upon request from higher layers to evaluate candidate beams in a first NBI-RS set, the UE indicates to higher layers whether there is at least one periodic CSI-RS configuration index and/or SS/PBCH block index from the first NBI-RS set with corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, and provides the periodic CSI-RS configuration indexes and/or SS/PBCH block indexes from the first NBI-RS set and the corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, if any. * For multi-TRP BFR, upon request from higher layers to evaluate candidate beams in a second NBI-RS set, the UE indicates to higher layers whether there is at least one periodic CSI-RS configuration index and/or SS/PBCH block index from the second NBI-RS set with corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, and provides the periodic CSI-RS configuration indexes and/or SS/PBCH block indexes from the second NBI-RS set and the corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, if any. | Support: Convida  Concern: |

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| Company | Technical views |
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* 1. Simultaneous reception of signals with different QCL-typeD assumption

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| **#** | **Issue and proposals** | **Companies’ views** |
| 3.1 | Alt1: **To enhance priority rule to facilitate UE  to receive downlink  signals with two different QCL -TypeD properties, e.g. PDCCH QCL prioritization rule enhancement**  Alt2: **To release some scheduling restrictions which mandate gNB to schedule downlink  signals with the same QCL -TypeD property or prohibit to schedule some downlink  signals overlapped in time domain, e.g. PDSCH + SSB** | Alt1:  Support: Spreadtrum (Rel.16 rule applied for each TRP), ZTE, Qualcomm (for each CooolsetPool), LGE  Concern:  Alt2:  Support:  Concern; |
| 3.2 | NW provides indication of antenna group ID to DL channel/RS | Support: ZTE  Concern: |
| 3.3 | Type of combinations to be enhanced:  Case 1: PDCCH+PDCCH  Case 2: PDCCH+PDSCH  Case 3: CSI-RS + CSI-RS | Case 1:  Support: Spreadtrum, MediaTek, LGE  Concern:  Case 2:  Support: Spreadtrum, MediaTek,  Concern:  Case 3:  Support: Lenovo/MM,  Concern: |
| 3.4 | Study both S-DCI and M-DCI | Support: DOCOMO  Concern: |

Companies are invited to share their views below. From the FL’s perspective, it appears that there are some interests on Alt-1 (issue 3.1), at least for the case of PDCCH + PDCCH simultaneous reception.

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| Company | Technical views |
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Offline proposal:

1. Previous agreements
   1. RAN1#102-e

**Agreement**

For L1-RSRP, consider measurement / reporting enhancement to facilitate inter-TRP beam pairing

* Option-1: Group-based reporting,
  + e.g., beam restriction to facilitate inter-TRP pairing.
* Option-2: Non-group-based reporting

**Agreement**

Evaluate and study at least but not limited to the following issues for multi-beam enhancement

* Issue 1: Consideration of inter-beam interference
* Issue 2: For group-based reporting, increased number of groups and/or beams per group
* Issue 3: UE Rx panel related beam measurement/report
  + NOTE: “UE panel” is used for discussion purpose only

**Agreement**

* Evaluate enhancement to enable per-TRP based beam failure recovery starting with Rel-15/16 BFR as the baseline.
* Consider following potential enhancement aspects to enable per-TRP based beam failure recovery
  + Issue 1: TRP-specific BFD
  + Issue 2: TRP-specific new candidate beam identification
  + Issue 3: TRP-specific BFRQ
  + Issue 4: gNB response enhancement
  + Issue 5: UE behavior on QCL/spatial relation assumption/UL power control for DL and UL channels/RSs after receiving gNB response

**Agreement**

Study Rel.17 enhancements on beam management for multi-TRPs with following priority

* High priority:
  + Beam measurement/reporting enhancement
  + Beam failure recovery for multi-TRP
* Low priority
  + Simultaneous reception of same type of channel/RS with different QCL-TypeD
  + Simultaneous reception of different type of channel/RS with different QCL-TypeD
  1. RAN1#103-e

Agreement

Down-select at least one of the following options for beam measurement/reporting enhancement to facilitate inter-TRP beam pairing in RAN1 #104-e

* Option 1: In a CSI-report, UE can report N>1 pair/groups and M>=1 beams per pair/group
  + Different beams in different pairs/groups can be received simultaneously
  + FFS: whether M is equal or can be different across different pair/group
* Option 2: In a CSI-report, UE can report N(N>=1) pairs/groups and M (M>1) beams per pair/group
  + Different beams within a pair/group can be received simultaneously
* Option 3: UE report M(M>=1) beams in N (N>1) CSI-reports corresponding to N report setting
  + Different beams in different CSI-reports can be received simultaneously
  + FFS: whether/how to introduce an association between different CSI-reports
  + FFS: whether/how to differentiate reported measurements for beams that are received simultaneously vs. beams that are not received simultaneously
    - whether/how to introduce an indication along with the CSI-reports to indicate whether the beams in different CSI-reports can be received simultaneously
* FFS: value of N and M in each option
* FFS: Association between different beams in above options and different TRP/UE panels
* FFS: Identify new use cases per option compared with R16 (including backhaul)
* FFS: whether different beams in different pairs/groups/reports can be received by same spatial filter per option

**Agreement**

* For M-TRP beam failure detection, support independent BFD-RS configuration per-TRP, where each TRP is associated with a BFD-RS set.
  + FFS: The number of BFD RSs per BFD-RS set, the number of BFD-RS sets, and number of BFD RSs across all BFD-RS sets per DL BWP
  + Support at least one of explicit and implicit BFD-RS configuration
    - With explicit BFD-RS configuration, each BFD-RS set is explicitly configured
      * FFS: Further study QCL relationship between BFD-RS and CORESET
    - FFS: How to determine implicit BFD-RS configuration, if supported
* For M-TRP new beam identification
  + Support independent configurat**i**on of new beam identification RS (NBI-RS) set per TRP if NBI-RS set per TRP is configured
    - FFS: detail on association of BFD-RS and NBI-RS
    - Support the same new beam identification and configuration criteria as Rel.16, including  L1-RSRP, threshold

Agreement

* Support TRP-specific BFD counter and timer in the MAC procedure
  + The term TRP is used only for the purposes of discussions in RAN1 and whether/how to capture this is FFS

Agreement

* Support a BFRQ framework based on Rel.16 SCell BFR BFRQ
  + In RAN1#104-e, select one from the following options
    - Option 1: Up to one dedicated PUCCH-SR resource in a cell group
      * A cell group refers to either MCG, SCG, or PUCCH cell group
      * FFS: number of spatial filters associated with the PUCCH-SR resources
      * FFS: How the SR configuration is done
    - Option 2: Up to two (or more) dedicated PUCCH-SR resources in a cell group
      * A cell group refers to either MCG, SCG, or PUCCH cell group
      * FFS: whether each PUCCH-SR resource is restricted to be associated to one spatial filter
      * FFS: How the SR configuration is done
  + FFS: Whether no dedicated PUCCH-SR resource can be supported in addition to Option 1 or Option 2
* Study whether and how to provide the following information in BFRQ MAC-CE
  + Index information of failed TRP(s)
  + CC index (if applicable)
  + New candidate beam index (if found)
  + Indication whether new beam(s) is found
  + FFS: whether/how to incorporate multi-TRP failure
  1. RAN1#104-e

**Agreement**

For beam measurement in support of M-TRP simultaneous transmission

* Support a single CSI-report consisting of N beams pairs/groups and M (M>1) beams per pair/group, and different beams within a pair/group can be received simultaneously
  + Support M = 2
  + Support extending the maximum value of N > 1, exact value FFS
  + N=1 and N=2
    - FFS: Other values larger than 2
    - FFS: Whether the UE could report beams are received with different RX beams
* Further study the support of option 1 and option 3
* The above applies at least for L1-RSRP
  + FFS: L1-SINR

**Agreement**

* For M-TRP BFR Support 1-to-1 association between each BFD-RS set and an NBI-RS set
  + FFS: Association details

**Agreement**

For M-TRP BFR

* Support 2 BFD-RS sets per BWP, and up to N resources per BFD-RS set
  + FFS: value of N (e.g. fixed in specification, or UE capability)
* FFS: number of BFD RSs across all BFD-RS sets per DL BWP (e.g. fixed maximum value or UE capability)

**Agreement**

For BFRQ of M-TRP BFR

* Option 3: Up to two dedicated PUCCH-SR resources in a cell group
* FFS: Whether PUCCH-SR for SCell can be reused for M-TRP
* Support BFRQ MAC-CE that can convey information of failed CC indices, one new candidate beam for the failed TRP/CC (if found), and whether new candidate beam is found
  + Support at least indication of a single TRP failure
    - FFS: whether/what information of failed TRP(s) is conveyed in the MAC-CE
    - FFS: whether/how to support indication of more than one TRP failure, corresponding BFR procedure, and applicable cell type (SCell vs. SpCell)
* FFS: UE behavior when TRP failure status is different across cells
* FFS: Whether PUCCH SR resource can be configured with 2 spatial relations
  1. RAN1#104b-e

**Agreement**

For beam reporting option 2

* On the maximum number of beam pairs/groups (N) that can be reported in a single CSI-report, discuss and down-select from the following two alternatives in RAN1#105-e:
  + Alt1: Support maximum value N = {1, 2}
  + Alt2: Support maximum value N = {1, 2, 3, 4}
* FFS: Introduce a UE capability Ncap on the maximum value of N in Rel.17
* On the number of beam pairs/groups (N) reported in a single CSI-report, discuss and down select between the following two alternatives in RAN1#105-e
  + Alt1: The value of N is fixed by RRC configuration
  + Alt2: The value of N is upper bounded by a maximum value Nmax configured by RRC, and dynamically selected/indicated by UE

**Agreement**

On CMR resource configuration for beam reporting option 2, adopt the following alternative:

* Two CMR resource sets or subsets, per periodic/semi-persistent CMR resource setting
  + FFS: extension to aperiodic CMR resource setting
* Each reported beam pair in a single CSI-report consists of M = 2 SSBRI / CRI values, where each SSB-RI / CRI points to a CMR resource in a different CMR resource set or subset.
* Decide in RAN1#104b-e whether to adopt “set” or “subset” in the above.

**Agreement**

* Support simultaneous configuration of cell-specific BFR and TRP-specific BFR in different CCs.
* FFS: whether cell-specific and TRP-specific BFR can be configured in the same CC.

**Agreement**

* Support S-DCI and M-DCI in TRP-specific BFR in Rel.17
  + S-DCI is low priority, M-DCI is high priority
  + Unified design for S-DCI and M-DCI should not be precluded due to the prioritization

**Agreement**

On BFD-RS of TRP-specific BFR

* BFD-RS resource number:
  + The total number of RSs in two BFR-RS sets per DL BWP is a UE capability
  + On the maximum number of RS per BFD-RS set, down-select from the following two alternatives in RAN1#105-e
    - Alt1: max value is 2
    - Alt2: max value is a UE capability, including possible candidate value of 1

**Agreement**

Adopt the following beam failure detection criteria for each BFD-RS set

* The physical layer in the UE assesses the radio link quality per BFD-RS set and indicates the BFD-RS set index to higher layers every X ms, if the hypothetical PDCCH BLER of all BFD-RS in the corresponding set of BFD-RS is higher than a threshold
  + X is max{minimal periodicity of BFD RS in the set, 2ms}

**Agreement**

A UE configured with TRP-specific BFR can be configured with 1 PUCCH-SR resource in a cell group

* NOTE: it has been agreed in RAN1#104-e that a UE can be configured with up to 2 PUCCH-SR resources in a cell group

**Agreement**

For the TRP specific BFR, for a UE configured with two PUCCH-SR resources in a cell group when beam failure is detected in a one or more CCs in one or more of BFD-RS sets configured in one or more of CCs,

* Down select one of the following PUCCH-SR resource selection rules when SR is triggered (or their combinations) for the study, without precluding other alternatives, in RAN1#105-e
  + Alt-1: PUCCH-SR resource associated with other/non-failed BFD-RS set, association details FFS
  + Alt-2: PUCCH-SR resource associated with failed BFD-RS set, association details FFS
  + Alt-3: Leave it up to UE implementation
* Note: PUCCH-SR resource is PUCCH resource carrying SR
* FFS: Whether two PUCCH-SR resources are under the same or different SR resource configuration or SR configuration (eventual decision may or may not happen in RAN1)

**Agreement**

On CMR resource configuration for beam reporting option 2, decide in RAN1#105-e whether to adopt “set” or “subset”:

* NOTE: the following has been agreed
  + Two CMR resource sets or subsets, per periodic/semi-persistent CMR resource setting
    - FFS : extension to aperiodic CMR resource setting if two CMR resource sets are supported
  + Each reported beam pair in a single CSI -report consists of M = 2 SSBRI/CRI values, where each SSBRI /CRI points to a CMR resource in a different CMR resource set or subset.
* FFS : bitwidth of each SSBRI/CRI determined based on the number of SSB/CSI-RS resources from the associated set/subset, or across two sets/subsets

1. Reference
2. R1-2103858, “Moderator summary #1 on beam management enhancement for M-TRP with multiple Rx panels”, Moderator (CATT)
3. R1-2103906, “Moderator summary #2 on beam management enhancement for M-TRP with multiple Rx panels”, Moderator (CATT)
4. R1-2103996, “Moderator summary #3 on beam management enhancement for M-TRP with multiple Rx panels”, Moderator (CATT)