**3GPP TSG RAN WG1 Meeting #104-e R1-210nnnn**

**E-meeting, January 25th – February 5th, 2021**

Source: Moderator (CATT)

Title: Moderator summary on M-TRP simultaneous transmission with multiple Rx panels (round 0)

Agenda Item: 8.1.2.3

Document for: Discussion and Decision

1. Background

This is a FL summary of Rel.17 MIMO AI 8.1.2.3, beam management for M-TRP simultaneous transmission with multiple Rx panels.

# Discussion

This section captures company views on a list of issues with relative high interest. Please note that this summary may not be exhaustive, where issues with less interests/inputs from companies are omitted and postponed for later discussion.

* 1. Issue 1: Beam measurement/reporting for inter-TRP simultaneous transmission

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| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **notes** |
| 1.1 | Beam pair/group reporting option * Option1: 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 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

  | Option 1: * Yes: OPPO (L1-RSRP), ZTE, AT&T, Sony, APT, Xiaomi, Apple, Lenovo
* No:

Option 2: * Yes: Futurewei, OPPO(L1-SINR), HW/HiSi, Lenovo, ZTE, Intel, AT&T, Spreadtrum, APT, Nokia/NSB, CMCC, ETRI, Xiaomi, Samsung, Qualcomm, DOCOMO, Ericsson,
* No: Apple

Option 3:* Yes: HW/HiSi, vivo, MediaTek, AT&T, Nokia/NSB, CATT
* No:
 | Majority for option 2, while option 1 and option 3 has some (almost equal) interests  |
| 1.2  | max # of beams (M) increased beyond 2  | * Yes: OPPO (option 1, up to 4, when N = 2), ZTE (up to 4), vivo (option 3, up to 4), Intel, DOCOMO (up to 4, when N = 2, option 1), APT (at least for Option 1)
* No: Futurewei, ETRI, Samsung, Ericsson, Intel (TBD), Spreadtrum
 | There are some concerns on increasing M.  |
| 1.3.  | max # of pair/group (N)  | * N = 2: Spreadtrum
* N = 3: Ericsson
* N = 4: Futurewei, OPPO (option 2, up to 4, when M = 2), HW/HiSi, ZTE, vivo, Nokia/NSB, ETRI, Samsung, Apple, Qualcomm, DOCOMO (option 2), CATT
* N = TBD: Intel
 | No major concern seen against increasing N. Value can be FFS.  |
| 1.4 | Association between different beams to TRP * Option 1: one CMR set per CMR setting, w/ higher-layer configured TRP identifier (e.g. sub-set ID) per resource
* Option 2: multiple CMR sets per CMR setting, each assumed associated to a TRP
* Option 3: Introduce CellID and TRPID in TCI-state
* Option 4: Grouping SSB/CSI-RS by higher-layer configuring
 | Option 1: * Yes: CATT, Qualcomm, OPPO
* No:

Option 2* Yes: HW/HiSi, ZTE, Intel, Apple, CATT, DOCOMO, Qualcomm
* No:

Option 3: * Yes: Futurewei
* No:

Option 4: * Yes Nokia/NSB
* No:
 |  |
| 1.5 | Association between different beams to UE panels/antenna groups* Option 1: report of panel-ID / antenna group ID
* Option 2: introduce separate hypotheses where different UE panels are associated with different or same TRP beams
 | Option 1: * Yes: Samsung, ZTE, DOCOMO, Qualcomm, InterDigital, Xiaomi
* No: OPPO

Option 2: * Yes: Intel, CATT
* No: OPPO
 |  |
| 1.6 | Support modeling of interference across beams, w/ L1-SINR | * Yes: ZTE, OPPO, HW/HiSi, Xiaomi, CATT, Qualcomm, DOCOMO, Lenovo, Intel, Futurewei
* No: vivo, Apple
 | Concern from 1 company |
| 1.7 | Whether different beams can be received by the same spatial filter per option  | * Yes:
* No:
 |  |

**Draft Proposal 1.1**: For beam measurement in support of M-TRP simultaneous transmission with multiple Rx panels

* Support at least option 2, where a single CSI-report consists 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 extending the maximum value of N beyond 1, exact value FFS
	+ FFS extending the maximum value of M > 2
* Further study the support of option 1 and option 3

**Draft Proposal 1.2**:

* For option 2, support configuration of S>1 CMR resource sets corresponding to a periodic/semi-persistent CMR resource setting or an aperiodic trigger state
	+ UE reports M beams (e.g. CMR resources) from S>1 CMR resource sets
	+ NOTE: UE is not allowed to assume that CMR resources in the same CMR set can be received simultaneously
	+ FFS: whether S = M

**Draft Proposal 1.3**:

* As a working assumption, support modeling of interference across beams for simultaneous M-TRP transmission

Table 1: Additional company inputs: issue 1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Lenovo&MotM | Support all the proposals. |
| DOCOMO | For Proposal 1.1, M=2 and N=1 have been supported in Rel-16. We suggest proposing N can be larger than 1, FFS 2 or 4 or other values. And for Option 2, we do not see the need to have M>2. M=2 will be sufficient for NCJT TX with two TRPs.For Proposal 1.2 and 1.3, generally fine. |
| InterDigital | Overall, we support FL’s proposals. For Proposal 1.1, we don’t think the sub-bullet is necessary, as we already know M>2.On issue 1.5, we support Option 1: reporting the panel ID.  |
| Futurewei | Our views are updated in the table above.Support FL’s Proposals 1.1, 1.2, and 1.3. |
| MediaTek | On proposal 1.1: Support, even we also prefer Option 3.On proposal 1.2* Since multiple CMR resource sets are already supported for an aperiodic resource setting in Rel-16 (but only one CMR resource set can be associated with an aperiodic trigger state). To avoid confusion, we suggest to have separated descriptions for P/SP and AP resource settings, respectively.
* We believe the number of CMR resource sets should be equal to M in Option 2, however, this can be further discussed
* According to current description, it is not quite clear for us how UE reports beams from these CMR resource sets for each pair/group.

We suggest the following update.**Draft Proposal 1.2**: * For option 2, support configuration of ~~multiple~~ S>1 CMR resource sets corresponding to a periodic/semi-persistent CMR resource setting or an aperiodic trigger state
	+ UE ~~is allowed to~~ reports M beams (e.g. CMR resources) from S>1 CMR resource sets per pair/group ~~, which can be received simultaneously~~
	+ NOTE: UE is not allowed to assume that CMR resources in the same CMR set can be received simultaneously
	+ FFS: Whether S = M
 |
| APT | Proposal 1.1: we agree with DCM’s view. Otherwise, that makes no much difference from Rel-15/16 behavior. Proposal 1.2: support in principle |
| Huawei, HiSilicon | **Support the FL’s proposals:**For Proposal 1.1, we support the proposal, and we also support Option-3 for Non-grouping case.Also support FL’s Proposal 1.2 and 1.3.  |
| vivo | For Proposal 1.1, we prefer Option 3 considering following reasons:* The overhead of UCI reporting is minimum with Option 3 when the number of reported beams is the same. Detailed analysis can be seen in Table 1 in our companion contribution R1-2100424.
* For non-ideal backhaul MTRPs, considerable throughput gain can be achieved by Option 3 which is verified by simulation results in Table 2 to 5 in our companion contribution R1-2100424.

Note: correct one issue on the simulation results in in Table 2 and Table 3. Simulation results with rotation speed setting to 50rpm should be exchanged with that with rotation speed setting to 150rpm.* Implementation of Option 3 has minimum specification impact. For example, to achieve simultaneous transmission, associating more than one CSI reporting setting, each corresponding to one TRP in Option 3 may cause report-level changes on current configuration framework, while configuring TRP identifier per CMR resource or multiple CSI resource sets(Proposal 1.2) in one CSI resource setting, where each set corresponds to one TRP in Option 1 and Option 2 may cause /set-level changes. In addition, Option 3 could reuse legacy configuration and operation.

For Proposal 1.2, it has already been agreed in MTRP CSI enhancement that the CMR from different TRPs would be put in the same set. Similar framework should be used for MTRP BM and for MTRP CSI. For Proposal 1.3, we don’t support interference measurement model in MTRP transmission scheme that directly regarding one CMR resource in one beam pair as the interference of another CMR resource to calculate L1-SINR. The result of L1-SINR may reflect the inter-beam interference, but it can’t reflect the quality of the simultaneous reception. And the reported beam pair based on L1-SINR even may degrade throughput performance. Combined the simulation results in Table 6 in our companion contribution R1-2100424, it is verified that throughput performance based on L1-SINR report is much worse than that based on L1-RSRP report.  |
| Samsung | We support proposal 1.1 in principle (we see the need of N > 1 but not M > 2, and we are fine to discuss option 3). We also support FL’s proposals 1.2 and 1.3. |
| NEC | Support the proposals. |
| OPPO | Proposal 1.1We agree with DCM’s view on Option 2. Moreover, when L1-RSRP is configured as reporting metric, interference cannot be indicated and considering back to back panel mode at UE, we think Option 1 can be supported and signaling overhead can be saved.For Proposal 1.2Multiple CMR resource sets can only be supported with aperiodic resource setting, Furthermore, if multiple CMR resource sets are agreed for one resource setting with 3 kinds of time domain behavior, we think the number of resource sets are 2. Then there is confliction on how to interpret the CMR resource sets for aperiodic resource setting because one resource set is associated with each trigger state in Rel-15. Thus, we add some modifications on Proposal 1.2**Draft Proposal 1.2**: * For option 2, support configuration of ~~multiple~~two CMR resource subsets in a CMR resource set corresponding to a CMR resource setting
	+ UE is allowed to report beams (e.g. CMR resources) from different CMR resource subsets, which can be received simultaneously
	+ NOTE: UE is not allowed to assume that CMR resources in the same CMR subset can be received simultaneously
	+ FFS: a specific ID can be used to differentiate CMR resource subsets in a CMR resource set.
 |
| Xiaomi | Support proposal 1.1 in principle but we don’t know the scenario for the FFS with extending the maximum value of M > 2.Support proposal 1.2 in principle but we have one point for clarification. It is about the “NOTE”, in which it noted that “UE is not allowed to assume that CMR resources in the same CMR set can be received simultaneously”. We want to know that is it necessary to add one more “NOTE” on the CMR resources in the different CMR set?Support proposal 1.3. |
| Apple | Do not support proposal 1.1 and 1.3.There is no way to measure inter-beam interference as shown in the figure below. So no benefit for option 2. |

* 1. Issue 2: M-TRP Beam failure recovery

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| **#** | **Issue** | **Companies’ views** | **notes** |
| 2.1 | Support S-DCI vs. M-DCI Option 1: M-DCI only Option 2: S-DCI and M-DCI  | Option 1: * Yes: OPPO, MediaTek, Fujitsu, Lenovo/MotM
* No:

Option 2: * Yes: vivo, CATT, LGE, Intel, AT&T, APT, CMCC, Samsung, Ericsson, DOCOMO, Qualcomm, Futurewei, Convida, NEC, Xiaomi
* No: OPPO, Apple
 |  |
| 2.2.  | Max # of BFD-RS sets per BWPOption 1: 2Option 2: 10 Option 3: Other (please specify)  | Option 1: * Yes: Apple, LGE, Xiaomi, CONVIDA, Ericsson, CATT, Huawei/HiSi, ZTE, MediaTek, Intel, NEC, Lenovo/MotM, DOCOMO, Qualcomm, InterDigital, Futurewei, APT, OPPO

Option 2: * Yes:
* No: Apple
 | Option 1 appears to be the majority view |
| 2.3 | Max # of BFD-RS resources per set Option 1: 2 Option 2: UE capability Option 3: 10 | Option 1: * Yes: LGE, CONVIDA, ITRI, Ericsson, HW/HiSi, Lenovo/MotM, Futurewei, MTK, NEC, Xiaomi
* No: Apple

Option 2: * Apple, Qualcomm, OPPO

Option 3:* InterDigital
* Not: Apple
 | Option 1 appears to be the majority view |
| 2.4 | Max # of BFD-RSs across all BFD-RS sets per DL BWPOption 1: 4Option 2: 20Option 3: Other (please specify) | Option 1: * Yes:
* No: Apple

Option 2: * Yes: InterDigital
* No: Apple

Option 3:* UE capability: Qualcomm, InterDigital, MTK (but up to 4), Apple
 |  |
| 2.5 | BFD-RS generation when all CORESET have a single TCI state Option 1: **Explicit configuration** of set k (k=0,1, …) Option 2: **Implicit configuration** of set k, based on TCI of CORESET set k (k = 0, 1, …)Option 3: **Implicit configuration** of set k, based on TCI of CORESET set k with k = CORESETPoolIndex   | Option 1: * Yes: HW/HiSi (both S/M), ZTE (also MAC-CE based update), vivo, MediaTek, LGE, Fujitsu, Spreadtrum, NEC, APT, CMCC (S/M), ETRI, Samsung, Apple, CONVIDA, Qualcomm, ITRI, DOCOMO, Ericsson (both S/M), CATT (both S/M, with possible MAC-CE update), InterDigital, Futurewei, NEC, Xiaomi
* No: Lenovo

Option 2: * Yes: Samsung, CATT, Intel, AT&T,
* No: Apple

Option 3: * Yes: OPPO, InterDigital, HW/Hi, ZTE, vivo, MediaTek, LGE, Qualcomm, ITRI, DOCOMO, Ericsson, Lenovo/MotM, Futurewei, APT (for M-DCI), NEC, Xiaomi
* No
 |  |
| 2.6 | BFD-RS generation, when CORESET has two TCI state Option 1: based on both TCI states | Option 1: * Yes: Ericsson, DOCOMO, Qualcomm, Convida, Apple
* No:
 |  |
| 2.7 | Association between BFD-RS set k and NBI-RS set j * Option 1: 1-to-1 association, k=j,
* Option 2: left to RAN2
 | Option 1: * Yes: Lenovo, ZTE, MediaTek, LGE, Intel (set id *k*), Fujitsu, Nokia/NSB, CMCC, ETRI, Xiaomi, Apple, CONVIDA, DOCOMO, HW/HiSi, Qualcomm, InterDigital, Futurewei, APT, NEC
* No:

Option 2: * Yes: Convida
* No:
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| 2.8 | Support RACH-based fallback, * FFS condition
 | * Yes: vivo, ZTE, Intel/DOCOMO(SpCell when both TRP fail), Lenovo/MotM, Qualcomm, Apple
* No: CMCC (postpone after BFRQ), Xiaomi, Futurewei ,OPPO
 |  |
| 2.9 | PUCCH-SR * Option 1: up to 1 PUCCH-SR resource with 1 spatial filter
* Option 2: up to 1 PUCCH-SR resource with 2 spatial filters
* Option 3: up to 2 PUCCH-SR resources with 1 spatial filter each
	+ NOTE: it is assumed that one PUCCH-SR is selected for beam failure event feedback
 | Option 1: * Yes: Lenovo (SCell), LGE (???) , Fujitsu, CATT, Convida,
* No:

Option 2:* Yes: Samsung. Xiaomi, Qualcomm, DOCOMO, Ericsson, InterDigital, MediaTek
* No:

Option 3: * Yes: OPPO, HW/HiSi, Lenovo (PCell), ZTE, vivo, Intel (1-to-1 association to BFD-RS set), AT&T, Nokia, ASUSTek, CMCC, ETRI, Apple, ITRI, DOCOMO, Spreadtrum, Futurewei,
* No:
 |  |
| 2.10 | BFRQ MAC-CE: Consists of failed CC indices, a new candidate beam per failed TRP/cell (if found), and * Option 1: failed TRP index
* Option 2: no failed TRP index
 | Option 1:* Yes: HW/HiSi, Lenovo, ZTE, MediaTek, Sony, Nokia/NSB, Qualcomm, DOCOMO (suggest to revise the main bullet as ‘new candidate beam per failed TRP/Cell’ by adding ‘/Cell’), InterDigital, OPPO, Sony, Futurewei, APT, NEC, Xiaomi
* No:

Option 2: * Yes: CMCC, CATT (if two PUCCH-SR resources), Apple, CONVIDA (w/ proposal), vivo
 |  |
| 2.11 | gNB response Option 1: * Reuse Rel.16 SCell-BFR mechanism (e.g. DCI with toggled NDI scheduling a same HARQ process ID as the PUSCH carrying BFRQ MAC-CE)

Option 2: * MAC-CE activation/updating CORESET beams of failed TRP
 | Option 1: * Yes: ZTE, MediaTek, CATT, Intel, Qualcomm, DOCOMO, vivo, MediaTek, Lenovo/MotM, APT, NEC
* No:

Option 2: * Yes: Vivo
* No:
 |  |
| 2.12 | Simultaneous configuration of cell-specific BFR and TRP-specific BFR* NOTE: need to clarify if this is about configuration on the same CC or different CC
 | * Yes: Xiaomi (SpCell), Lenovo/MotM, Futurewei, vivo, Apple
* No: Spreadtrum, CATT, Qualcomm, MTK (TRP-specific BFR naturally supports cell-specific BFR), OPPO
* DOCOMO: For different CCs, different BFR schemes can be configured. For the same CC, it is not clear what the simultaneous configuration means, and we just need to clarify UE behavior.
 |  |
| 2.13 | UE assumption after reception of gNB responseIssue 1: If a single TRP declared beam failure* Option 1.1: update by new beam for failed link

Issue 2: If both TRPs declared beam failure* Option 2.1: Each TRP is updated by its latest reported new beam (if found)
* Option 2.2: (please specify)

Issue 3: update for which channels* Option 3.1: at least PDCCH/PUCCH
 | Issue 1: Option 1.1: * Yes: OPPO, Fujitsu, DOCOMO (SpCell and SCell), CATT, Lenovo/MotM, Qualcomm, MTK, APT, Convida, NEC, Apple

Issue 2: Option 2.1: * Yes: OPPO, Fujitsu, Apple, CATT, MTK, Convida
* No: vivo (Cell specific BFR procedure is triggered)

Issue 2: Option 2.2: * Yes: DOCOMO (For a SCell with both TRPs beam failure, only a new beam is reported for the SCell in the MAC CE, and the new beam is applied to the failed serving cell, or applied to the first TRP only), Qualcomm (If both TRPs fail, RACH based BFR will be used to identify a single new beam to recover the whole cell if it is PCell, identified new beam per TRP will be used to recover each TRP if it is SCell)

NEC: We share similar view with DoCoMo on Scell, only one new beam is reported if both TRPs failed, and whether the new beam is applied to the Scell or only one TRP can be further discussed.* No:

Issue 3: option 3.1: * Yes: Qualcomm, OPPO (Support PDCCH but PUCCH need more dicussion), Lenovo/MotM, DOCOMO (association between PUCCH and BFD-RS set), MTK, APT, NEC, Apple
 |  |
|  |  |  |  |

**Proposal 2.1**: 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

**Proposal 2.2**: BFD-RS configuration

* Support explicit RRC configuration of BFD-RS set, for both S-DCI and M-DCI
* Support implicit configuration of BFD-RS set
	+ If all CORESETs in a BWP are configured with one TCI
		- BFD-RS set k (k = 0, 1 …) is based on TCI state of CORESETs in CORESET subset k (k = 0, 1...)
		- For M-DCI, CORESET subset k consists of CORESETs with *CORESETPoolIndex = k (i.e.* BFD-RS set ID k (k = 0, 1 …) is equal to *CORESETPoolIndex = k)*
		- FFS: decided in RAN1#104-e whether/how to support implicit configuration for S-DCI
	+ FFS: if at least one CORESET is configured with multiple TCI states

**Proposal 2.3**:

* Support 1-to-1 association between BFD-RS set and NBI-RS set with the same set ID k (k = 0, 1...).

**Proposal 2.4**: BFRQ

* In RAN1#104-e, down-select from the following options :
	+ Option 1: Up to one dedicated PUCCH-SR resource in a cell group, with one spatial filter for each PUCCH-SR resource
	+ Option 2: Up to one dedicated PUCCH-SR resources in a cell group, with two spatial filter for each PUCCH-SR resource
	+ Option 3: Up to two dedicated PUCCH-SR resources in a cell group, with one spatial filter for each PUCCH-SR resource
		- For option 2 and 3, study the selection of PUCCH-SR resource(s) and the spatial filter
* Support BFRQ MAC-CE that can convey information of at least failed CC indices, one new candidate beam per failed TRP/CC (if found), and whether new candidate beam is found
	+ Support at least the case of one TRP failure
		- FFS: whether information of failed TRP(s) is conveyed in the MAC-CE
		- FFS: whether/how to support the case of more than one TRP failure

**Proposal 2.5**: gNB response

* Support the same gNB response as in Rel.16 SCell BFR (i.e. DCI with toggled NDI scheduling a same HARQ process ID as the PUSCH carrying BFRQ MAC-CE)
* .

Table 2: Additional company inputs: issue 2

|  |  |
| --- | --- |
| **Company** | **Input** |
| Lenovo&MotM | For proposal 2.1, support the proposal.For proposal 2.2, only supported implicit configuration.For proposal 2.3, support the proposal.For proposal 2.4, support the proposal.For proposal 2.5, support the proposal.For proposal 2.6, not supported since the closed loop indexes of PUCCH resources associated with different TRPs may be different as discussed in 8.1.2.1. We can’t reuse the R16 mechanism directly. |
| DOCOMO | For proposal 2.1, support.For proposal 2.2, do not support implicit configuration for S-DCI. (FL: added a deadline to decide in RAN1#104-e)For proposal 2.3, support.For proposal 2.4, support.For proposal 2.5, support.For proposal 2.6, too early to decide it. It is related to whether allowing one or two new beam ID reporting in MAC CE in case of two TRPs failure. |
| Qualcomm | For 2.1, we can define max configured #. Detailed supported # should be UE capabilityFor 2.2, supportFor 2.3, supportFor 2.4, not support 2 PUCCH resources. Prefer a single PUCCH for all BFR purposes to save overhead.For 2.5, supportFor 2.6, support |
| InterDigital | For proposal 2.1, support the proposal.For proposal 2.2, support the proposal.For proposal 2.3, support the proposal.For proposal 2.4, do NOT support the proposal.For proposal 2.5, neutral.For proposal 2.6, neutral  |
| Futurewei | Our views are updated in the table above.Proposal 2.1, support FL’s proposal.Proposal 2.2, support FL’s proposal.Proposal 2.3, support FL’s proposal.Proposal 2.4, support FL’s proposal.Proposal 2.5, support FL’s proposal.Proposal 2.6, need further discussion. |
| MediaTek | Support Proposal 2.1.OK to support Proposal 2.2 and Proposal 2.3. However, set ID may not be provided if BFD-RS set is implicitly configured. We are not pretty sure whether Proposal 2.2 implies BFD-RS set ID can be determined according to CORESETPoolIndex? If yes, we prefer to add one item in Proposal 2.2 to address the concern:**Proposal 2.2**: BFD-RS configuration* Support explicit RRC configuration of BFD-RS set, for both S-DCI and M-DCI
* Support implicit configuration of BFD-RS set
	+ If all CORESETs in a BWP are configured with one TCI
		- BFD-RS set k (k = 0, 1 …) is based on TCI state of CORESETs in CORESET subset k (k = 0, 1...)
		- For M-DCI, CORESET subset k consists of CORESETs with *CORESETPoolIndex = k*
		- BFD-RS set ID k (k = 0, 1 …) is equal to *CORESETPoolIndex = k*
		- FFS: whether/how to support implicit configuration for S-DCI
	+ FFS: if at least one CORESET is configured with multiple TCI states

NOT support Proposal 2.4. Support Proposal 2.5.Further discuss Proposal 2.6 after previous issues are stable/concluded. |
| APT | Proposal 2.1: Support in generalProposal 2.2: Support in principle. In addition, the last FFS is one important topic needed to be addressed. Option 1 in Issue 2.6 would be a starting point, but further details are necessary. Proposal 2.3: SupportProposal 2.4: We think failed TRP index is needed to be reported. Otherwise, network has no clue that which TRP is failed, and which TRP is the NCB aimed for. Proposal 2.5: SupportProposal 2.6: Support in principle. But further discussion is needed.  |
| Convida Wireless | Proposal 2.1: supportProposal 2.2: For the first sub-sub-bullet, are there any other cases for “CORESET subset” than two CORESET pools? If not, the first and second sub-sub-bullet could be merged into one case.Proposal 2-3: We support “1-to-1 association between BFD-RS set and NBI-RS set”. However, we think RAN2 can decide the signaling details, for example an explicit set index in each BFD-RS/NBI-RS, or a second list for the second set, or another way.Proposal 2-4: Suggest breaking this up into two proposals.For the first bullet, we don’t support. PUCCH is typically on the SpCell in FR1, so we don’t think we should spend time to design a special solution for two spatial relations. If necessary, we think the solution should be based on the work in multi-TRP PUCCH agenda item. For the second bullet, we support it. However, could we agree that failure of both TRPs can be indicated at least for SCell? Otherwise, gNB will think that the second TRP-link of the SCell is working.Proposal 2-5: SupportProposal 2-6: Support |
| Huawei, HiSilicon | **For Proposal 2.1**: Support.**For Proposal 2.2**: Generally we are fine for the proposal, but not support implicit indication for S-DCI cases.**For Proposal 2.3**: Generally we are fine. But the “with the same set ID k (k = 0, 1...)” may need to some further discussion, since the mapping can be without the ID mapping, such as first BFD-RS set is associated with the first NBI-RS set, the second BFD-RS set is associated with the second NBI-RS set, in the BFD-RS set list and NBI-set list.**For Proposal 2.4**: Generally we are fine for the proposal. But one parameter is missing which is in Rel-16 BFR: *“****whether no new candidate beam”.*****For Proposal 2.5**: Support.**For Proposal 2.6**: Support. |
| vivo | For **Proposal 2.4:*** In RAN1#104-e, down-select from the following options :
	+ Option 1: Up to one dedicated PUCCH-SR resource in a cell group, with one spatial filter for each PUCCH-SR resource
	+ Option 2: Up to one dedicated PUCCH-SR resources in a cell group, with two spatial filter for each PUCCH-SR resource
	+ Option 3: Up to two dedicated PUCCH-SR resources in a cell group, with one spatial filter for each PUCCH-SR resource
		- For option 2 and 3, study the selection of PUCCH-SR resource(s) and the spatial filter
* Support BFRQ MAC-CE that can convey information of at least failed CC indices, one new candidate beam for the failed TRP/CC (if found), and whether new candidate beam is found
	+ Support at least the case of one TRP failure
		- FFS: whether information of failed TRP(s) is conveyed in the MAC-CE
		- FFS: whether/how to support the case of more than one TRP failure
 |
| Samsung | We support FL’s proposals in principle. For proposal 2.4, we would like to suggest a minor edit on one FFS point:* + - FFS: whether/what information of failed TRP(s) is conveyed in the MAC-CE
 |
| NEC | Proposal 2.1, support.Proposal 2.2, support.Proposal 2.3, support.Proposal 2.4, support, and prefer option 2.Proposal 2.5, support. |
| OPPO | Proposal 2.1: SupportProposal 2.2: Only support implicit configuration, Considering TCI states can be updated by MAC CE which means explicit method for BFD-RS configured by RRC cannot always represent the beam from CORESET.Proposal 2.1: SupportProposal 2.1: SupportProposal 2.1: SupportProposal 2.1: Need further discussion on PUCCH. |
| Xiaomi | For proposal 2.1, support.For proposal 2.2, support. For proposal 2.3, support.For proposal 2.4, support the proposal, and we prefer Option 2.For proposal 2.5, support.  |
| Apple | Our views are provided in the Table |

* 1. Issue 3: Simultaneous reception of signals with different QCL-TypeD

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| --- | --- | --- | --- |
| **#** | **Issue** | **Companies’ views** | **notes** |
| 3.1 | Introduce at least one of the following methods should be considered when beam collision between different DL channel(s) and RS(s) occurs. * Alt 1: UE can prioritize the reception of a DL channel or RS with higher priority.
* Alt 2: UE can use a predefined beam to receive the conflicting DL channels or RSs.
* Alt 3: UE can use the indicated beam and corresponding panel to receive the DL channel or RS with higher priority, and meanwhile UE can use the other active panel and a predefined beam to receive the other DL channel or RS with lower priority.
 | Support: ZTE |  |
| 3.2 | * Support to enhance on DL SPS PDSCH reception for multi-DCI based multi-TRP case.
* In overlapping PDSCH without corresponding PDCCH transmissions receiving occasions from multiple TRP, one PDSCH with lowest configured sps-ConfigIndex for each TRP could be received.
* PDSCH without corresponding PDCCH transmission associates with the same value of CORESETPoolIndex as CORESET where PDCCH activating the PDSCH lies in.
 | Support: Spreadtrum |  |
| 3.3 | In multi-DCI based mTRP, the existing QCL prioritization rule for overlapped CORESETs should be applied within CORESETs with same CORESETPoolIndex. | Support: Qualcomm |  |
| 3.4 | Release some constraints due to QCL-TypeD collision for UEs that can receive two beams simultaneously, where the starting point is to release the constraints for SSB/CSI-RS for RLM/BFD/CBD. | Support: Apple |  |
| 3.5 | * + Support a higher layer signaling to indicate whether to enable simultaneous reception of multiple channels/RSs with different QCL-TypeD at UE.
	+ Discuss UE behavior for S-DCI and M-DCI separately
 | Support: DOCOMO: |  |

Table 3: Additional company inputs: issue 3

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| --- | --- |
| **Company** | **Input** |
| Lenovo&MotM | We have the same view with Apple on “Release some constraints due to QCL-TypeD collision for UEs that can receive two beams simultaneously”. In addition to mentioned SSB/CSI-RS for RLM/BFD/CBD, simultaneous transmission on PDCCH and simultaneous transmission on CSI-RS for beam management can be also discussed. |
| Huawei, HiSilicon | These issues are low priority for discussion. |
| Apple | The objective is to handle simultaneous reception related BM enhancement, we suggest we list potential study points for next steps. |

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. Company views

|  |  |  |
| --- | --- | --- |
| R1-2100040 | Beam management for simultaneous multi-TRP transmission with multi-panel reception | FUTUREWEI |
| Proposal 1: FeMIMO supports Option 2 for beam measurement/reporting enhancement to facilitate inter-TRP beam pairing: 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
* Support N = 1, 2, 4, and M = 2

Proposal 4: FeMIMO supports BFD-RS are QCLed with PDCCH DMRS with respect to 'QCL-TypeD' assuming that the Rel-17 unified TCI framework supports M>1 DL TCIs such that each of the TCI provides QCL information for UE-dedicated reception on a subset of CORESETs in a CC.  |
| [R1-2100066](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100066.zip) | Discussion on M-TRP Beam Management Enhancements | InterDigital, Inc. |
| Proposal 1: For BFD-RSs and BFD-RS sets,* Keep the same number of BFD-RS per set (10) as Rel-15/16
* Increase the number of BFD-RS sets to 2
* Increase max number of BFD-RSs across all BFD-RS sets per DL BWP to 20

Proposal 2: Support both explicit and implicit BFD-RS configuration with CORESETs. Proposal 3: In multi-DCI case, support implicit determination of failed RS based on CORESETPoolIndex. Obsevation 4: NBI-RS and BFD-RS sets can be considered as a collection of RS sets which can be identified per TRP. Then, a UE can identify the NBI-RS per TRP based on the BFD-RS set that failed.Proposal 4: Support one-to-one association of the NBI-RS set to the BFD-RS set.Proposal 5: Support up to one dedicated PUCCH-SR resource in a cell group (Option 1) with one spatial filter per TRP.Observation 6: Simultaneous declaration of BFR by both TRPs represents a severe case of beam failure, and hence it requires the quickest and most reliable response.Proposal 6: If beam failure is detected at both TRP simultaneously, the BFR associated to TRP1 or PCell should be prioritized. Proposal 7: Include index information of failed TRPs in BFR MAC-CE.  |
| R1-2100121 | Enhancements on beam management for multi-TRP | OPPO |
| Observation 1: Option 1 is more efficient than Option 2 when the UE use separate panel(s) to receive beams and measure L1-RSRP of each beam from two different TRPs.Observation 2: Option 2 can support the measurement of inter-TRP interference but Option 1 cannot.Proposal 2: Support Option 1 with L1-RSRP measurement and support Option 2 with L1-SINR measurement:* In Option 1: UE reports N = 2 groups of M = 1/2/4 CRI/SSBRI and corresponding L1-RSRP. The CRI/SSBRI reported in 1st group are for CMR resources for 1st TRP and the CRI/SSBR reported in 2nd group are for CMR resources for 2nd TRP.
* In Option 2: UE reports N =1/2/4 groups of M = 2 CRI/SSBRIs in each group and L1-SINR measurement. In each reporting group, one CRI/SSBRI is for CMR of 1st TRP and another CRI/SSBRI is for CMR of 2nd TRP. The L1-SINR of each reported CRI/SSBRI is calculated by using the paired CRI/SSBRI as interference.

Proposal 3: Do not support pe-TRP BFR enhancement for single-DCI based system Proposal 4: For multi-TRP BFR, only support implicit BFD-RS configuration* For each TRP, the UE derives the BFD-RS set according the TCI states configured to the CORESETs associated with the CORESETPoolIndex = 0 or 1.
* The number of BFD-RS in each per-TRP BFD-RS set is <= 2.

Proposal 5: Support to associate new beam identification RS set with CORESETPoolIndex value = 0/1. Proposal 6: Support to configure two Schedule request configurations in MAC-CellGourpConfig for per-TRP BFR:* Each schedule request configuration is associated with one TRP.

Proposal 7: The multi-TRP BFRQ MAC CE carries the following information:* A value of CORESETPoolIndex 0/1 to indicate which TRP has beam failure
* CC index
* A New beam RS index if found.

Proposal 8: UE switches the QCL of CORESETs associated with the CORESETPoolindex value with beam failure to qnew after TRP-specific BFRQ is received successfully.Proposal 9: Discuss whether and how to support the association between PUCCH resource and TRP so that we can support the UE to updating the Tx beam of PUCCH resource after per-TRP BFRQ. |
| R1-2100211 | Multi-panel reception for multi-TRP in Rel-17 | Huawei, HiSilicon |
| Proposal 1: For group based beam reporting, Option 2, i.e., beams in a group can be simultaneously received by UE, should be supported.Proposal 2: For non-group-based beam reporting, Option-3, i.e., beams in different CSI-reports can be simultaneously received by UE, should be supported. Proposal 3: The number of beam groups in group-based beam reporting can be 1, 2, or 4.Proposal 4: Support configuring two resource sets in one resource setting with each resource set associated with a TRP.Proposal 5: Mutual interference between the reported beams should be considered for L1-SINR calculation in group based beam reporting.Proposal 6: Support both explicit and implicit BFD-RS configuration for M-DCI case, whilst support explicit BFD-RS configuration only for S-DCI case.* In explicit BFD-RS configuration, two BFD-RS sets are configured for two TRPs respectively.
* In implicit BFD-RS configuration, source RSs of QCL for the CORESETs associated with the same CORESETPoolIndex are regarded as a BFD-RS set.

Proposal 7: Support 1-to-1 association between BFD-RS set and NBI-RS set.Proposal 8: Support configuring two BFD-RS set, each associated with at most 2 BFD-RS resources.Proposal 9: Support to configure two dedicated PUCCH-SR resources, each associated with one spatial relation.Proposal 10: The following contents are included in BFRQ:* RS index corresponding to new candidate beam
* Indication of un-qualified candidate beam
* Index information of failed TRP
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| [R1-2100276](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100276.zip) | Enhancements on beam management for multi-TRP | Lenovo, Motorola Mobility |
| Proposal 1: To support single-DCI based multi-TRP DL transmission, UE can report N(N>=1) beam pairs in a CSI-report. Different beams within a pair can be received simultaneously.Proposal 2: To support multi-DCI based multi-TRP DL transmission, UE can report two groups and M>=1 beams per group in a CSI-report. Different beams in different  groups can be received simultaneously.Proposal 3: Include inter-TRP interference in L1-SINR in group based beam reporting.Proposal 4: For group based beam reporting, UE should be aware which resources for channel measurement are transmitted from the same or different TRPs.Proposal 5: Further study gNB’s response for beam failure request per TRP and UE’s behavior after receiving the response after BFD-RS set and NBI-RS set configuration and beam failure reporting per TRP are determined.Proposal 6: Only support implicit BFD-RS configuration for TRP-specific BFRQ and determine the BFD-RS set index by its associated CORESETPoolIndex value.Proposal 7: Associate a BFD-RS set with a NBI-RS set by a predefined/fixed rule.Proposal 8: Discuss TRP-specific BFRQ in PCell and SCell separately for PUCCH-SR resource configuration.Proposal 9: Support Option 2 for PUCCH-SR resource configuration if TRP-specific BFRQ is configured in PCell.Proposal 10: Further study whether the PUCCH-SR resource configured for SCell BFRQ can be reused for TRP-specific BFRQ in PCell.Proposal 11: Support Option 1 for PUCCH-SR resource configuration if TRP-specific BFRQ is configured in SCell.Proposal 12: Reuse the PUCCH-SR resource configured for SCell BFRQ for TRP-specific BFRQ in SCell.Proposal 13: When multi-TRP operation and multiple BFD-RS sets are configured in a cell, two bits can be contained in the cell bitmap for this cell in the BFR MAC CE, where each bit is used to indicate where beam failure is detected on the corresponding TRP in the carrier.Proposal 14: Increase the number of SRS resource set configured for antenna switching to obtain the channel information between each TRP of multiple TRPs and a UE.Proposal 15: Further study simultaneously receiving PDCCH+PDCCH and simultaneously receiving CSI-RS+CSI-RS with different QCL-TypeD if time is available.  |
| R1-2100288 | Enhancements on beam management for Multi-TRP | ZTE |
| Proposal 1: Support both Option 1 (antenna group based reporting) and Option 2 (beam group based reporting) for multi-TRP operation.* Option 1 (antenna group based reporting) is used for mDCI-mTRP and/or facilitating panel-specific DL and UL beam management via RSRP reporting;
* Option 2 (beam group based reporting) is used for sDCI-mTRP and/or optimizing inter-beam inference in SINR reporting
* Information on grouping one or more RS(s) (e.g., beam group ID, or antenna group ID) can be reported along with RS ID(s) and RSRP/SINR in a report instance.

Proposal 3: Extension of Rel-15 group based beam reporting should be considered to support more Tx beams and/or more groups to be reported in Rel-17 NR-FeMIMO.* Regarding Option 1 (antenna group based reporting), UE can be configured to report N (N= 2, 3, 4) groups and M (M =1, 2, 3, 4) beams per group.
* Regarding Option 2 (beam group based reporting), UE can be configured to report N (N=1, 2, 3, 4) groups and M (M = 2, 3, 4) beams per group.

Proposal 4: A CSI-RS resource set corresponds to a TRP transparently, and for multi-TRP operation, more than one CSI-RS resource sets can be configured for CSI resource setting.* The following restriction/requirement can be configured for beam group based report (i.e., different RSs within a reported group can be received simultaneously).
	+ Reporting restriction-1: the maximum number of CSI-RS in a set, e.g., 1, 2 or 4, to be reported in a group, in order to inform TRP related simultaneous transmission capability implicitly.
	+ Reporting restriction-2: at least one CSI-RS resource from one CSI-RS resource set to be reported for facilitating inter-TRP beam pairing.
* FFS: restriction/requirement for antenna group based reporting (i.e., different RSs from different reported group can be received simultaneously)

Proposal 5: Regarding TRP-specific BFR, * R16 mDCI-mTRP case should have high priority, considering non-ideal backhaul.
* Other cases, such as R16 sDCI-mTRP and R17 mTRP (spatial repetition for PDCCH/PUSCH/PUCCH), are postponed after R16 mDCI-mTRP is stable.

Proposal 6: Support TRP-specific BFD RS and NBI RS through associating CORESETPoolIndex with BFD RS and NBI RS in mDCI-mTRP.* For BFD, explicit and implicit methods are both supported for determining BFD RS per CORESETPoolIndex
	+ Explicit: Two separate BFD RS sets, q\_0(s), are configured per CORESETPoolIndex, and a RS of each of q\_0(s) should be QCL-ed with a CORESET with a CORESETPoolIndex corresponding to the q\_0
	+ Implicit: Two separate BFD RS sets, q\_0(s), are determined according to TCI states of CORESETs per CORESETPoolIndex

Proposal 7: Introduce a new MAC-CE to activate BFD RS(s) dynamically, in order to guarantee the same timeline between PDCCH beam update and explicit BFD RS configuration.Proposal 8: Regarding BFRQ for TRP-specific BFR, Option 2: Up to two (or more) dedicated PUCCH-SR resources in a cell group is supported, in order to handle the case that PUCCH transmission corresponding to a failed TRP may also fail.* When up to two (or more) dedicated PUCCH-SR resources in a cell group are configured, association between one of PUCCH-SR resource(s) and CORESETPoolIndex should be supported for mDCI-mTRP.

Proposal 9: The beam for CORESET/PUCCH should be updated according to a reported candidate RS, only if the CORESET/PUCCH is associated with the same CORESETPoolIndex corresponding to BFD and NBI RS sets.* CORESETPoolIndex is introduced for PUCCH configuration, in order to initialize TRP-specific CORESET and PUCCH’s beam update
* Deactivating CORESET(s) associated with the same CORESETPoolIndex, if no candidate RS can be identified.

Proposal 10: TRP-specific BFR procedure can be applied to SPCell(s) besides SCell(s).* FFS: condition to trigger PRACH for TRP-specific BFR in an SPCell, e.g., any TRP(s) fails, all TRPs fail or just a specific TRP fails.

Proposal 11: In multi-panel reception, DL channel(s) and RS(s) can be associated with the information about antenna group(s).* Study mechanism(s), e.g., associating CORESET group(s) or TCI state(s) with antenna group(s).

Proposal 12: In the case of multi-TRP transmission with UE multi-panel reception, at least one of the following methods should be considered when beam collision between different DL channel(s) and RS(s) occurs. * Alt 1: UE can prioritize the reception of a DL channel or RS with higher priority.
* Alt 2: UE can use a predefined beam to receive the conflicting DL channels or RSs.
* Alt 3: UE can use the indicated beam and corresponding panel to receive the DL channel or RS with higher priority, and meanwhile UE can use the other active panel and a predefined beam to receive the other DL channel or RS with lower priority.
* FFS: definition of beam collision between different DL channel(s) and RS(s), e.g., different QCL Type D RS(s) under the same panel.
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| R1-2100346 | Enhancements on beam management for multi-TRP | CATT |
|  |  |  |
| R1-2100424 | Further discussion on MTRP multi-beam enhancement | vivo |
| 1. Rel-17 MTRP beam reporting enhancement should take into account both ideal backhaul and non-ideal backhaul scenarios to support simultaneous transmission at network side and simultaneous reception at the UE side.
2. Support Option 3 for multi-TRP beam report enhancement.
3. Support explicit association of different CSI report settings, each corresponding to a TRP.
4. Support N equals the number of TRPs and M=1, 2, 4 in Option 3.
5. For Option 3, support that any pair of combinations of different beams from different reports can be received simultaneously by same spatial filter or different spatial filters.
6. For beam measurement, L1-RSRP reporting is prioritized. Do not support L1-SINR report with interference calculated between the reported beam pair.
7. TRP-specific BFR should be applicable to both multi-DCI-based MTRP and single-DCI-based MTRP.
8. Two sets of BFD-RS can be explicitly configured for both multi-DCI-based MTRP and single-DCI-based MTRP.
9. Two sets of BFD-RS can be implicitly configured for multi-DCI-based MTRP, each including P-CSI-RS indexes with QCL-typeD for PDCCH monitoring associating with one of the two values of CORESETPoolIndex.
10. Support more than one new beam selection from the TRPs other than the TRP in beam failure.
11. For TRP-specific new candidate beam identification,

If BFR occurs for one TRP, the UE can select a new beam other than the one pointing to the TRP in good radio link.For the case when both TRPs fail, UE can still follow existing behavior to find a single new beam and use the existing CFRA-based BFRQ procedure.1. Support Option 2, i.e., up to two (or more) dedicated PUCCH-SR resources in a cell group.

A PUCCH-SR resource associated with a BFD-RS set of one TRP can be configured with the spatial filter towards the other TRP.1. For TRP-specific BFRQ,

For the case of BFR of one TRP, the PUSCH transmitting the MAC CE for BFRQ can be selected towards the TRP in good radio link.For the case of BFR of both TRPs, use the CFRA or CBRA to transmit the BFRQ.1. Following information should be provided in BFRQ MAC CE

Index of the BFD-RS set associated with the failed TRPCC index (if applicable)New candidate beam index(es) (if found)Indication whether new beam(s) is found1. When UE detects both beam links to two TRPs fail, legacy process on receiving the network response can be applied if only one new beam has been reported in the BFRQ.
2. For the case of BFR of one TRP, a UE can receive the following signaling as BFRR in addition to legacy BFRR:

a MAC CE activation command to update the TCI states for the CORESET(s) related to the TRP/BFD-RS set in beam failure.1. For a UE operating with multi-DCI-based MTRP, if it has reported the new beam, the UE may reset the beams of the channels from some time after receiving BFRR:

For the case of BFR of one TRP, the UE may reset the beam to the new beam for the PDCCH and PDSCH associating with the CORESETPoolIndex which has been declared beam failure.For the case of both TRPs in beam failure, the UE can fall back to single TRP reception, resetting the beam to the new beam for all CORESETs associating to one CORESETPoolindex.For the case when BFRR is a MAC CE activation command to update the TCI states, UE reset the beam according to the beam indication in the MAC CE.1. For a UE operating with single-DCI-based MTRP, if it has reported the new beam, the UE may reset the beams of the channels according to the indicated beams in the BFRR. For this case, BFRR is a MAC CE activation command to update the TCI states for the CORESET(s) related to the TRP/BFD-RS set in beam failure
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| R1-2100589 | Enhancements on beam management for multi-TRP | MediaTek Inc. |
| Proposal 1: Per-TRP-based BFR is supported only when two CORESET pools are provided for a BWP.Proposal 2: For independent BFD-RS configuration per-TRP, support both explicit and implicit manners to provide up to two BFD-RS sets.* Explicit manner: Each CORESET pool is associated with one BFD-RS set provided by RRC
* Implicit manner: BFD-RS set for a CORESET pool is determined from the TCI state(s) indicated for the CORESETs that are associated with the CORESET pool

Proposal 3: Support up to two BFD RSs per BFD-RS set, up to two BFD-RS sets per BWP, and up to four BFD RSs per BWP.Proposal 4: Association between a CORESET pool and a NBI-RS-set is needed. Proposal 5: On LLR for TRP-specific BFR, support up to one dedicated PUCCH-SR resource in a cell group as in Rel-16, and any PUCCH enhancement for multi-TRP should be discussed in AI 8.1.2.1.Proposal 6: BFRQ MAC-CE can be enhanced to support TRP-specific BFRQ by providing the following:* Indication of the failed CORESETS pool(s)
* Indication of the CC(s) where CORESETS pool(s) is failed
* Indication of whether new beam(s) is identified for the failed CORESETS pool(s)
* Index(s) of the new beam(s) identified for the failed CORESETS pool(s), if any

Proposal 7: Support using BFRQ MAC-CE to indicate TRP-specific beam failure and TRP-specific new beam RS ID for SpCell in any PUSCH.Proposal 8: On gNB response, reuse the same rule defined for Rel-16 SCell BFR without change.Proposal 9: For TRP-specific BFR, if UE declares beam failure for a CORESET pool in a cell using a BFRQ MAC-CE, after a duration from UE detects gNB response to the BFRQ MAC-CE, UE shall monitors PDCCH in all CORESETs belonging to the CORESET pool in the cell using the new beam identified for the CORESET pool in the BFR MAC-CE, if any.Proposal 10: Beam measurement/reporting enhancement is needed to facilitate inter-TRP beam pairing with non-ideal inter-TRP coordination.Proposal 11: Support at least Opt3 for beam measurement/reporting enhancement to facilitate inter-TRP* NW can associate 2 report settings by higher-layer signaling
* UE reports up to 4 DL RSs in each of CSI-reports corresponding to the 2 associated report settings
* UE indicates whether the DL RSs in different CSI-reports can be received simultaneously by UE
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| R1-2100621 | Enhancements on beam management for multi-TRP | LG Electronics |
| Proposal #1: Beam management enhancement can be considered for multiple pairs of TRP-UE panel.Proposal #2: Support option 2 for group-based beam reporting to facilitate inter-TRP beam pairing. N is {1, 2, 4}, and M is 2.Proposal #2: Support option 2 for group-based beam reporting to facilitate inter-TRP beam pairing. N is {1, 2, 4}, and M is 2.Proposal #3: With option 2, L1-SINR based NCJT beam pair reporting can be considered by reporting best N beam pair(s), each of which corresponds to (NZP-CSI-RS of TRP# 1, NZP-CSI-RS of TRP #2).Proposal #4: Support option 3 for non-group-based beam reporting to facilitate inter-TRP beam pairing. M can be maximum 4 as legacy beam reporting, and N is 2.Proposal #5: Consider beam measurement and reporting enhancement for different TDD DL/UL configuration across multiple TRPs.Proposal #6: Support both implicit and explicit BFD-RS configuration.* For implicit BFD, TRP-specific BFD can be performed for a specific CORESET pool or per CORESET pool by default
	+ Further consider gNB configuration of CORESET group(s) within a CORESET pool when only one CORESET pool exists in the BWP.

Proposal #7: Support 1-to-1 association between BFD-RS set and NBI-RS set.Proposal #10: Clarify the BFD behavior for Rel-17 BFR and for Rel-15/16 BFR when two TCI states are configured for a CORESET.Proposal #9: Beam determination for PDSCH should also be investigated according to the enhanced beam indication for M-TRP PDCCH, e.g., PDCCH repetition and SFN based PDCCH transmission from M-TRP. Proposal #11: Clarify UE behavior when CORESET with multiple QCL type-D RSs is overlapped with another CORESET(s). |
| R1-2100639 | Multi-TRP enhancements for beam management | Intel Corporation |
| Proposal-1: Support option 1 with N=2. M>=1 with max M value TBD.Proposal-2: Associate two CSI-SSB-ResourceSets, each representing a TRP/panel in a CSI-ResourceConfig (when mTRP measurement and reporting is enabled) Proposal-3: For Rx panel related feedback, specify an indication for mTRP (simultaneous) reception hypothesis or sTRP reception hypothesis. mTRP hypothesis means a) L1-RSRP reported is based on reception from the selected best UE Rx panel (and not based on reception due to multiple panels) and b) L1-SINR reported includes interference due to the other reported beam-pair. sTRP hypothesis means a) L1-RSRP reported may be based on reception from one or more Rx panels and b) L1-SINR reported includes interference due to other cells.Proposal-4: For interference measurement corresponding to mTRP reception hypothesis, include interference due to the paired beam for L1-SINR reportingProposal-5: In order to increase the efficiency of CSI reporting, reporting multiple beam-pairs (M>=1) in a single instance of group-Based beam reporting may be supported. |
| [R1-2100739](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100739.zip) | Enhancements on beam management for multi-TRP | Fujitsu |
| Proposal 1: Support TRP-specific beam failure recovery on the basis of multi-DCI framework.Proposal 2: For M-TRP beam failure detection, support both explicit and implicit BFD-RS configuration.Proposal 3: For explicit BFD-RS configuration, each BFD-RS set should be configured with a CORESETPoolIndex for TRP identification.Proposal 4: For implicit BFD-RS configuration, CORESETPoolIndex can be used for the derivation of BFD-RS sets.Proposal 5: An NBI-RS set is associated with a BFD-RS set if they correspond to the same TRP (i.e. same value of CORESETPoolIndex).Proposal 6: For the down-selection of TRP-specific BFRQ, option 1 is preferred:* Up to one dedicated PUCCH-SR resource in a cell group

Proposal 6: For the down-selection of TRP-specific BFRQ, option 1 is preferred:* Up to one dedicated PUCCH-SR resource in a cell group

Proposal 7: If beam failure is detected in a TRP, the corresponding BFRQ shall at least convey the index of the failing TRP.Proposal 8: The multi-TRP enhancement on gNB response shall depend on agreements on TRP-specific BFRQ enhancement. Proposal 9: After a UE informs a beam failure event of a TRP and the corresponding gNB response is received, the UE shall adjust the transmission/reception parameters for the UL/DL associated with the TRP. |
| R1-2100780 | Enhancements on beam management for multi-TRP | AT&T |
| Proposal 1: L1-SINR measurement framework is used for multi-TRP joint transmission with multi-panel reception, in addition to L1-RSRPProposal 2: Group-based beam reporting enhancements based on option 2 should be specifiedProposal 3: Non-group based beam reporting enhancements based on option 3, and group based beam reporting based on option 1 can be considered in addition to option 2.Proposal 4: Support both implicit and explicit BFD-RS configurationProposal 5: Support implicit BFD-RS configuration where CORESETs in the BWP are divided into multiple groups (e.g. each corresponding to a TRP/panel) and the BFD-RS set k is implicitly derived from the corresponding CORESET group. Proposal 6: For per-TRP BFRQ, up to two (or more) dedicated PUCCH-SR resources per cell group can be used.  |
| [R1-2100786](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2100786.zip) | Discussion on enhancements on beam management for multi-TRP | Spreadtrum Communications |
| Proposal 1: For beam measurement/reporting enhancement to facilitate inter-TRP beam pairing, at least option 2 should be supported.Proposal 2: For option 2, the value of M could be 2.Proposal 3: For option 2, the value of N could be 2.Proposal 4: For option 2, different beams in the same pair can be received simultaneously by the UE either with a single spatial domain receive filter, or with multiple simultaneous spatial domain receive filters.Proposal 5: For TRP specific BFR, at least explicit BFD-RS set configuration could be supported.Proposal 6: For PUCCH-SR resource, option 2 could be supported, i.e., Up to two (or more) dedicated PUCCH-SR resources in a cell group could be configured.Observation 1: It is not necessary to configure both cell-specific and TRP-specific BFR.Proposal 7: Support to enhance on PDCCH reception for multi-DCI based multi-TRP case. Proposal 8: In overlapping PDCCH monitoring occasions in multiple CORESETs that have same or different QCL-TypeD properties on active DL BWP(s) from different TRPs, priority rule of monitoring in Rel-15 should be applied separately for each TRP.Proposal 9: Support to enhance on DL SPS PDSCH reception for multi-DCI based multi-TRP case. Proposal 10: In overlapping PDSCH without corresponding PDCCH transmissions receiving occasions from multiple TRP, one PDSCH with lowest configured sps-ConfigIndex for each TRP could be received.Proposal 11: PDSCH without corresponding PDCCH transmission associates with the same value of CORESETPoolIndex as CORESET where PDCCH activating the PDSCH lies in. |
| R1-2100847 | Considerations on beam management for multi-TRP | Sony |
| 1. In Rel.15/16, the group-based beam reporting was not optimized for multi-panel/multi-TRP operation.
2. In Rel.15/16, the specified group-based beam reporting (only single group and up to 2 Tx beams per group) seems too restrictive for multi-TRP operation.
3. RAN1 should enhance the group-based beam reporting for multi-TRP operation in following aspects
* Study and specify if necessary, the constraint on beam selection to facilitate the inter-panel/inter-TRP operation
* Study and evaluate the benefits of increasing the number of groups and/or beams per group, specify the enhancement correspondingly if necessary
1. For M-TRP, support Option 1 that a UE can report N>1 pair/groups and M>=1 beams per pair/group in a single CSI report. Different beams in different pairs/groups can be received simultaneously.
2. In Rel.17, RAN1 supports TRP-specific or partial BFR procedure including BFD, NBI, BFRQ, BFRR and UE behavior on automatic beam updating after successful BFR.
3. Support partial NBI from the TRP in which UE experiences beam failure.
4. From signaling perspective, the BFRQ MAC CE for multi-TRP should include failed TRP ID(s), CC index (if applicable), new candidate beam index (if any), and availability of new beam.
* CORESETPoolIndex can be used as TRP “ID” in BFRQ MAC CE.
1. Specify the QCL relationship among SRS resource sets/CSI-RS resource sets/SSBs on different BWPs/CCs (intra band).
2. Specify the QCL relationship among CSI-RS resource sets/SSBs on different directional antenna panels.
3. Specify the QCL relationship among SRS resource sets on different directional antenna panels.
4. A panel ID explicitly configured in spatialRelationInfo or unified TCI can be beneficial for panel specific operation.
5. A definition of “antenna panel” is needed to pave the road for the progress on multi-panel operation.
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| R1-2100951 | Discussion on beam management for multi-TRP | NEC |
| Proposal 1: Up to 2 sets of BFD RS are supported, and for explicit configuration, each CORESET with one active TCI state is associated with one BFD RS set. Implicit BFD RS configuration should be supported, and UE can determine each BFD RS set from corresponding CORESETs. Proposal 2: TRP specific beam failure recovery for SFN or non-SFN PDCCH transmission schemes should be further studied, for example, association between the BFD RS set and CORESET with two active TCI states, and UE behavior when one TRP is failed.  |
| R1-2100967 | Discussion of enhancements on beam management for Multi-TRP | Asia Pacific Telecom, FGI |
| Proposal 1: For facilitating inter-TRP beam pairing, support Option 1 and Option 2. * FFS: whether to further support Option 3

Proposal 2: Support TRP-specific beam failure recovery for both M-DCI and S-DCI based multiple TRP scenarios. Proposal 3: Support both explicit and implicit BFD-RS configuration for TRP-specific BFR procedure. Proposal 4: For TRP-specific BFD-RS, the following details are agreed: * The number of BFD-RS sets is two,
* The maximum number of BFD-RS(s) per set is two as starting point,
* The maximum number of all BFD-RS in a BWP is five.

Proposal 5: For PCell/PSCell, agree the followings for TRP-specific BFRQ* Do not introduce RACH-based BFRQ transmission as fallback mechanism for TRP-specific BFR;
* When both TRP-specific BFD-RS sets are measured below quality, UE transmits cell-specific BFRQ as Rel-15/16.

Proposal 6: For SCell, agree the followings for TRP-specific BFRQ* Do not introduce RACH-based BFRQ transmission as fallback mechanism for TRP-specific BFR;
* Postpone relationship between cell-specific BFRQ and TRP-specific BFRQ until the design of MAC-CE for TRP-specific BFRQ is ready.

Proposal 7: RAN1 to clarify BFD RS configuration and BFRQ triggering condition for a CORESET with two TCI states. |
| [R1-2101008](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101008.zip) | Enhancements on Beam Management for Multi-TRP/Panel Transmission | Nokia, Nokia Shanghai Bell |
| Proposal 2-1: Support Option 2 for ideal backhaul, and additionally support Option 3 for ideal/non-ideal backhaul scenario. Proposal 2-2: For group-based beam reporting for multi-TRP operation, introduce higher-layer configuration for grouping SSB resources such that associating TRP can be known to the UE. The grouping of CSI resources (SSB and NZP-CSI-RS) can be understood by the UE based on any of the following methods, * + Alt-1: Introduce the same higher-layer indication for grouping CSI- resources to associate with TRPs.
	+ Alt-2: Support SSB grouping (or TRP association) and QCL-typeD relationships between different RSs are used for grouping CSI-RS resources to associate with TRPs.

Proposal 2-3: For enhanced group-based beam reporting for multi-TRP, support up to 4 group beam-pairs for a group-beam report, i.e. M = 2 and N = 4. Proposal 2-4: Support reporting criteria associated with group based beam reporting that defines simultaneous reception to be ‘across-TRP/per-TRP’.* When the simultaneous reception criteria is configured to be ‘across-TRP’, UE shall only report N-different CSI resources (i.e. NZP-CSI-RS or SSB) that can be simultaneously received with multiple different spatial filters with spatial multiplexing capability.
* When the simultaneous reception criteria is configured to be ‘per-TRP’, UE shall only report N-different resources received with one (or more) spatial filters considering single TRP reception.

Proposal 2-5: Support beam reporting criteria that imposes UE to report only measured CSI resources being within a certain power window or above a power threshold.Proposal 2-7: Support the common enhanced group-beam reporting for both L1-RSRP and L1-SINR report. Proposal 2-8: For non-group based beam reporting, support association of a reporting setting to another reporting setting to ensure the UE’s simultaneous reception from multi-TRP for multi-DCI based multi-TRP scheme, * UE shall select beams to be reported with the consideration of the simultaneous reception from two TRP.

Proposal 2-9: For the association of CSI report settings, the associated CSI-ResportSettingID is included in the CSI-ReportSetting. Proposal 2-10: Study method to indicate beams simultaneous reception capability.Proposal 2-11: Support UE’s dynamic feedback of its capability about the simultaneous reception for the TCI codepoints signaled in PDSCH MAC-CE. Proposal 3-1: Support configuration of up to 2 beam failure detection resource sets (q0) per BWP.Proposal 3-2: Support configuration of beam failure detection resource sets (q0) per coresetPoolIndex value. Proposal 3-3: To cope with the increased maximum number of CORESETs with active TCI states the total maximum number of BFD-RS should be considered, at least in multi-TRP configuration. Proposal 3-4: If multiple sets of q0 are supported, each failure detection resource set is associated with a respective candidate beam reference signals list (candidateBeamRSList)Proposal 3-5: Support up to two (or more) PUCCH-SR resources in a cell group for mTRP BFR which is corresponding to a TRP* PUCCH-SR for BFR is configured with corresponding CORESETPoolIndex

Proposal 3-6: For PUCCH-SR for BFR, a spatial relation is mapped to a PUCCH resource by reusing the existing framework. Proposal 3-7: When PUCCH-SR for mTRP BFR is not configured, UE may use CBRA or available UL grant to transmit MAC CE for mTRP BFR. Proposal 3-8: MAC CE is used convey information on failed TRP index (i.e. coresetPoolIndex), failed CC index (also PCell), candidate availability and candidate beam RS index (if available)  |
| [R1-2101026](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101026.zip) | Discussion on beam management for multi-TRP | ASUSTeK |
| Proposal 1: Support Up to two (or more) dedicated PUCCH-SR resources in a cell group Proposal 2: The gNB configures SR configuration for M-TRP BFR via one of the two options:* Option 1: The network provides two SR configurations. Each SR configurations indicates a set of PUCCH resources.
* Option 2: The network provides one single SR configuration, where the SR configuration includes two set of PUCCH resources
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| [R1-2101035](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101035.zip) | Enhancements on beam management for multi-TRP | CMCC |
| Proposal 1: Support Option 2, in a CSI-report, UE can report N(N>=1) pairs/groups and M (M>1) beams per pair/group, where different beams within a pair/group can be received simultaneously.Proposal 2: Explicitly or implicitly TRP-specific indication can be configured for the beam management RSs to let UE know which RSs are from the same TRP.Proposal 3: For M-DCI, support both explicit and implicit BFD-RS configuration. For S-DCI, support explicit BFD-RS configuration.Proposal 4: For NBI-RS set, an index can be configured in each set to establish the association to a TRP .Proposal 5: For BFRQ transmission, up to two dedicated PUCCH-SR resources in a cell group can be configured. The BFRQ transmission should provide the information on whether new candidate beam is identified, and if yes, the new candidate beam index. |
| [R1-2101074](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101074.zip) | Enhancements on beam management for multi-TRP | ETRI |
| Proposal 1: Option 2, which can support L1-SINR based beam reporting considering inter-beam interference, is preferred for beam measurement/reporting enhancement to facilitate inter-TRP beam pairing.Proposal 2: The value N that can be supported could be 1, 2, or 4, and will be determined by further performance evaluations and discussions.Proposal 3: It is recommended to set the value M to 2 to avoid unnecessary extension of specification.Proposal 4: Support both explicit and implicit BFD-RS configuration as in Rel.15/16.Proposal 5: For implicit BFD-RS configuration, BFD-RS set for each TRP can be provided implicitly by the TCI states for the CORESETs with a given CORESETPoolIndex.Proposal 6: Support one-to-one association between NBI resource sets and BFD resource sets with the TRP-specific index such as CORESETPoolIndex.Proposal 7: Support Option 2 (Up to two or more dedicated PUCCH-SR resources in a cell group) for TRP-specific BFRQ, because a single spatial relation can be configured per PUCCH resource as in Rel-15/16.Proposal 8: The details on the contents of the beam failure information carried by BFRQ MAC-CE need to be further discussed. |
| [R1-2101095](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101095.zip) | Enhancement on beam management for Multi-TRP | Xiaomi |
| Proposal 1: Prefer Option 1 and Option 2.Proposal 2: UE need to know the association between RSs and TRP (or cell) to facilitate inter-TRP beam pairing by group based beam reporting. Proposal 3: To report at least L1-SINR considering the inter-TRP interference.Proposal 4: To indicate that beams in one group are received by a single panel or two different panels. Proposal 5: Support both explicit and implicit per-TRP BFD-RS configuration.Proposal 6: Implicit per-TRP BFD-RS configuration can be determined based on CORESETPoolIndex.Proposal 7: Whether or how to add the RS(s) indicated by TCI states of the CORESET with two TCI states into any BFD-RS sets depends on the value of its CORESETPoolIndex.Proposal 8: * Support up to two BFD RSs per BFD-RS set.
* Support up to two BFD-RS sets.
* Not support BFD RS across all BFD-RS sets.

Proposal 9: Support 1-to-1 association between BFD-RS set and NBI-RS set.Proposal 10: Support NBI-RS across all NBI-RS sets.Proposal 11: Support up to one dedicated PUCCH-SR resource in a cell group with up to two spatial filters.Proposal 12: Support to configure both cell-specific and TRP-specific BFR on SpCell only. And RACH-based fallback mechanism is unnecessary. |
| [R1-2101189](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101189.zip) | Enhancements on beam management for multi-TRP | Samsung |
| Proposal 1: For beam measurement/reporting enhancements to facilitate inter-TRP beam pairing * For group based beam reporting enhancements, support Option-2. Further,
	+ Support M = 2, N up to 4 and or configured by the network
	+ Each group/pair of resource indicators corresponds to a different receiving hypothesis at the UE characterizing, e.g., a RX panel(s) status
* For non-group based beam reporting enhancements, further study the use case
	+ Option-3 is applicable only if all the beams in different CSI-reports, except those for the same TRP, could be simultaneously received by the UE
	+ Associations between different CSI-reports are not needed

Proposal 2: Support reporting the RX panel information/status, e.g., RX panel ID, to the network along with thebeam measurement resultsProposal 3: For CSI measurement enhancements to enable group based beam reporting for multi-TRP, support: each CSI resource setting contains multiple CMR resource sets, with each CMR resource set associating with a coordinating TRPProposal 4: For BFR enhancements for multi-TRP, support both single-DCI and multi-DCI based multi-TRP frameworksProposal 5: Support both explicitly and implicitly configured BFD RSs for both multi-DCI and single-DCI based multi-TRP systems* For implicit BFD RSs configuration, support BFD RS set k (k = 0, 1) associating CORESETs subset k (k = 0, 1), which is suited for both single-DCI and multi-DCI based frameworks
* The NBI RS sets have a one-to-one correspondence to the BFD RS sets

Proposal 6: Enhancements on BFR procedures such as BFRQ transmission are needed for multi-TRP * Separate SR configurations and/or a common SR configuration with different PUCCH beams could be configured for the coordinating TRPs, and used for transmitting the BFRQ
* Specify UE’s behaviors in falling back to the single-TRP operation if the UE applies a reduced BFR procedure with one of the coordinating TRPs

Proposal 7: Specify UE behaviors of initiating/triggering partial BFR and full BFR for different multi-TRP settings.  |
| [R1-2101353](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101353.zip) | Views on Rel-17 multi-TRP BM enhancement | Apple |
| Proposal 1: For beam reporting, option 1 should be supported, where in a CSI-report, UE can report N>1 pair/groups and M>=1 beams per pair/group.Proposal 2: It should be supported that gNB can provide some information on whether two beams can be simultaneously transmitted or not for beam measurement and report * Support to configure an additional set of CMRs in a CSI-ReportConfig, and UE can assume any two beams in different CMR sets can be simultaneously transmitted.

Proposal 3: Support UE to report a state that it cannot identify beams that can be simultaneously received.Proposal 4: Support gNB to configure up to 2 BFD RSs sets* The maximum number of BFD RSs within a set can be reported by UE capability
* If the BFD RS sets are not configured, the RSs configured in the TCI state for CORESETs with a CORESETPoolIndex should be used for BFD for a TRP

Proposal 5: Support gNB to configure up to 2 CBD RSs sets* Each CBD RSs set corresponds to a TRP
* CBD RSs set and BFD RSs set should be one-to-one mapped

Proposal 6: For PUCCH-SR configuration, support option 2 (configuring up to 2 PUCCH-SR resources in a cell group)* Each PUCCH-SR corresponds to a TRP (BFD/CBD RS set)
* The BFR MAC CE can report new beam index(es), failed CC index(es) as well as indication on whether new beam(s) is found

Proposal 7: When both BFD RS sets fail, UE can fallback to use Rel-15/Rel-16 single-TRP BFR procedure to recover from beam failure* Support UE to report 2 new beam indexes, where each beam corresponds to a CBD RS set

Proposal 8: Support to release some constraints due to QCL-TypeD collision for UEs that can receive two beams simultaneously, where the starting point is to release the constraints for SSB/CSI-RS for RLM/BFD/CBD. |
| R1-2101416 | On Per-TRP Beam Failure Recovery | Convida Wireless |
| Proposal 1: Support both explicit and implicit configuration of BFD RS per TRP.Proposal 2: Implicit determination of the first BFD-RS set follows implicit determination in Rel-15/16, but based on the first CORESET pool. Similarly for the second BFD-RS set.Proposal 3: Support two BFD-RS sets, each with up to two BFD-RS.Proposal 4: The physical layer in the UE assesses the radio link quality per set of BFD RS and indicates the BFD RS set index to higher layers when the radio link quality of all BFD RS in the corresponding set of BFD RS is worse than a threshold.Proposal 5: The details of the association between BFD-RS sets and NBI-RS sets is left to RAN2.Proposal 6: The NBI-RS sets are disjoint.Proposal 7: The higher layers of a UE can request the physical layer to provide the indexes of candidate beam RS from a per-TRP set of candidate beam RS with L1-RSRP above a threshold, if any.Proposal 8: The dedicated PUCCH-SR is not enhanced in Rel-17, i.e. Option 1 is supported and the FFSs are not needed.Proposal 9: RAN1 should strive to avoid introducing a new BFR MAC CE and to support efficient reporting of both single-TRP and multi-TRP cells in the same BFR MAC CE.Proposal 10: The indication of failed cells (Ci) is reused from Rel-16 BFR MAC CE.Proposal 11: Down-select from the following options for the one or two octets that correspond to a failed serving cell in the BFR MAC CE:* Option 1: The BFR MAC CE includes two octets for the failed cell, regardless if one or both TRP links have failed.
* Option 2: The BFR MAC CE includes one octet for the failed cell, regardless if one or both TRP links have failed.
* Option 3: The BFR MAC CE includes one octet for the failed cell if one TRP link has failed, and two octets if both TRP links have failed.

Proposal 12: If an octet containing the AC field includes a new candidate beam RS, the TRP index can be implicitly determined from the new candidate beam RS. If an octet containing an AC field does not include a new candidate beam RS, then one of the inserted reserved bits can be used to indicate TRP index. |
| R1-2101449 | Enhancements on beam management for multi-TRP | Qualcomm Incorporated |
| Proposal 1: For group-based beam report, introduce beam set (or TRP) index per candidate beam. UE shall report simultaneously receivable beams with different beam set indices.Proposal 2: For L1-SINR based group report, gNB configures multiple candidate beam groups, among which UE reports beam group(s) such that the two beams per group can be received simultaneously.* The corresponding CMR/IMR per beam in each candidate group should be configured such that the reported L1-SINR per beam reflects cross-beam interference from the other beam in the group.

Proposal 3: For group-based beam report, it can be considered for UE to report throughput related metric per reported beam group, including sum of CQI, capacity, mutual info.Proposal 4: For group-based beam report, UE can report more than one beam group, which can be sorted based on metric per group.Proposal 5: For group report, gNB can signal the purpose (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).Proposal 6: For enhanced group report, support Option 2. * 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.

Proposal 7: For mDCI mTRP, support both explicit and implicit per-TRP BFD.Proposal 8: 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.
* In absence of QCL-TypeD RS, the single QCL source RS in the TCI state can be the implicit BFD RS.

Proposal 9: TRP specific BFD PHY indicator should be introduced to indicate each occurrence of TRP specific beam failure to the MAC layer.Proposal 10: Support up to one PUCCH-SR resource in a cell group.* Two candidate spatial relations can be configured for the one PUCCH-SR resource.
* Among the two spatial relations, UE can select the one not associated with failed TRP for transmission.
* The same PUCCH-SR can be triggered by both per-TRP BFR and SCell BFR.

Proposal 11: A CC can be configured with either per-TRP BFR or PCell/SCell BFR. A modified BFR MAC-CE from R16 can indicate corresponding BFR info per CC based on the configured BFR type.* If a CC is configured with per-TRP BFR, MAC-CE will indicate CC ID, failed TRP ID, new beam ID.
* If a CC is configured with SCell BFR, MAC-CE will indicate failed CC ID and new beam ID.
* If a CC is configured with PCell BFR, MAC-CE will indicate the failure event.

Proposal 12: If no dedicated PUCCH-SR or if cell level failure of PCell happens, the modified BFR MAC-CE can be transmitted via RACH procedure.Proposal 13: The gNB response to the modified BFR MAC-CE can be the DCI scheduling UL grant with same HARQ ID as the one carrying the modified BFR MAC-CE.* After 28 symbols from receiving the gNB response, at least PDCCH/PUCCH beam will be reset for the failed TRP if a candidate beam is reported for it.
* In presence of PDCCH repetition, the 28 symbols start from the last repetition.

Proposal 14: In multi-DCI based mTRP, the existing QCL prioritization rule for overlapped CORESETs should be applied within CORESETs with same CORESETPoolIndex.Proposal 15: For power saving, UE can request to disable the dual default PDSCH beams in mTRP. |
| [R1-2101568](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104-e/Docs/R1-2101568.zip) | Discussion on beam management for multi-TRP | ITRI |
| Proposal 1: Support both explicit and implicit BFD-RS configurationProposal 2: For implicit BFD-RS configuration, BFD-RS is derived from CORESETs with a given CORESETPoolIndexProposal 3: Up to two BFD-RS sets can be configuredProposal 4: For TRP-specific new candidate beam identification, each candidate beam RS is associated with a value of CORESETPoolIndexProposal 5: Support up to two dedicated PUCCH-SR resources, whether each PUCCH-SR resource is associated to one spatial filter |
| R1-2101600 | Discussion on beam management for MTRP | NTT DOCOMO, INC. |
| Proposal 1:* + For beam measurement/reporting enhancement,
	+ Support Option 2.
	+ Further study Option 1.
	+ Do not support Option 3.

Proposal 2:* + For Option 2, UE can report up to N=2 or 4 groups and M=2 beams per group, depending on UE capability.
	+ The reported two beams per group should consider inter-beam interference, if configured, at least for L1-SINR based measurement/reporting.
	+ For Option 1, UE can report N=2 groups and up to M=2 or 4 beams per group, depending on UE capability.
	+ Further study whether/how to associate a group with a UE panel.

Proposal 3:* + Per-TRP based BFD/BFR should be supported for multi-DCI based MTRP.
	+ Per-TRP based BFD/BFR can be also studied for single-DCI based MTRP.

Proposal 4:* + For multi-DCI based MTRP, support both explicit and implicit BFD-RS configurations for per-TRP based BFD/BFR.
	+ Two sets of BFD-RS, with each set associated with different CORESETPoolIndex, can be configured by RRC. If not configured, two sets of BFD-RS can be derived from QCL-TypeD RS of TCI state of CORESETs associated with different CORESETPoolIndex.
	+ For single-DCI based MTRP, support explicit BFD-RS configuration for per-TRP based BFD/BFR.
	+ Two sets of BFD-RS can be configured by RRC. If not configured, cell-specific implicit BFD-RS can be determined as Rel-16.
	+ If all the BFD-RS of one set is worse than the threshold, PHY layer in UE provides an indication to higher layers for corresponding TRP. Separate indications can be provided to higher layers for each TRP.

Proposal 5:* + For multi-DCI based MTRP, two sets of NBI-RS, with each set associated with different CORESETPoolIndex, can be configured for per-TRP based BFD/BFR. The set of BFD-RS and the set of NBI-RS associated with the same CORESETPoolIndex are implicitly associated.
	+ For single-DCI based MTRP, two sets of NBI-RS can be configured for per-TRP based BFD/BFR. The set of BFD-RS and the set of NBI-RS with the same set ID are implicitly associated.
	+ If beam failure is detected for one TRP, a NBI-RS can be provided to higher layers upon request from higher layers. Separate NBI-RS can be provided to higher layers for each TRP.

Proposal 6:* + For per-TRP based BFD/BFR on SpCell,
	+ in case of beam failure for one TRP, enhanced BFR MAC CE is transmitted, with an indication of failed TRP information, and an indication of NBI-RS for the failed TRP, if found.
	+ in case of beam failure for two TRPs, RACH-based BFR procedure should be triggered.
	+ For per-TRP based BFD/BFR on SCell,
	+ in case of beam failure for one TRP, enhanced BFR MAC CE is transmitted, with an indication of failed TRP information, and an indication of NBI-RS for the failed TRP, if found.
	+ in case of beam failure for two TRPs, enhanced BFR MAC CE is transmitted, with an indication of two TRPs failure, and an indication of NBI-RS for the failed cell, if found, for recovery to single-TRP operation.

Proposal 7:* + Up to one SR (SchedulingRequestId) can be configured for BFD/BFR in MCG/SCG. For this SR configuration per cell group, down select from
	+ Option1: one PUCCH resource with two configured spatial relations
	+ Option2: two PUCCH resources with one configured spatial relation for each PUCCH resource

Proposal 8:* + For MAC CE based BFRQ, the gNB response for BFR MAC CE in Rel-16 can be the baseline.

Proposal 9:* + If beam failure is detected for one TRP, UE behavior in Rel-16 after receiving gNB response for MAC CE based BFRQ can be applied to the failed TRP only.
	+ If beam failure is detected for two TRPs for a SCell, UE behavior in Rel-16 after receiving gNB response for MAC CE based BFRQ can be further discussed, e.g., applied to the failed serving cell, or applied to one TRP only.

Proposal 10:* + Support a higher layer signaling to indicate whether to enable simultaneous reception of multiple channels/RSs with different QCL-TypeD at UE.
	+ Discuss the UE behavior of simultaneous reception of multiple channels/RSs with different QCL-TypeD separately for single-DCI based MTRP and multi-DCI based MTRP cases.
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| R1-2101686 | On beam management enhancements for simultaneous multi-TRP transmission with multi-panel reception | Ericsson |
| [Proposal 1 For beam measurement/reporting enhancement to facilitate inter-TRP beam pairing, support Option 2 in NR Rel-17.](file:///D%3A%5C3GPP%5CRAN1%5C2021%5C2021.01%5CDocs%5CR1-21xxxxx_round0_mimo2c_v000.doc#_Toc61897380)[Proposal 2 For beam measurement/reporting enhancement to facilitate inter-TRP beam pairing, support M = 2 and N = 3 with Option 2 in NR Rel-17.](file:///D%3A%5C3GPP%5CRAN1%5C2021%5C2021.01%5CDocs%5CR1-21xxxxx_round0_mimo2c_v000.doc#_Toc61897381)[Proposal 3 In NR Rel-17, support both explicit and implicit BFD-RS configuration in order to support per-TRP beam failure detection.](file:///D%3A%5C3GPP%5CRAN1%5C2021%5C2021.01%5CDocs%5CR1-21xxxxx_round0_mimo2c_v000.doc#_Toc61897382)[Proposal 4 In NR Rel-17, support two BFD-RS resource sets and up to two BFD RSs per BFD RS set.](file:///D%3A%5C3GPP%5CRAN1%5C2021%5C2021.01%5CDocs%5CR1-21xxxxx_round0_mimo2c_v000.doc#_Toc61897383)[Proposal 5 In NR Rel-17, support explicit per-TRP BFD-RS configurations for both multi-DCI based multi-TRP and single-DCI based multi-TRP.](file:///D%3A%5C3GPP%5CRAN1%5C2021%5C2021.01%5CDocs%5CR1-21xxxxx_round0_mimo2c_v000.doc#_Toc61897384)[Proposal 6 In NR Rel-17, support implicit per-TRP BFD-RS configurations only for multi-DCI based multi-TRP.](file:///D%3A%5C3GPP%5CRAN1%5C2021%5C2021.01%5CDocs%5CR1-21xxxxx_round0_mimo2c_v000.doc#_Toc61897385)[Proposal 7 In NR Rel-17, support per-TRP BFD-RS configurations for both intra-cell and inter-cell multi-DCI based multi-TRP operation.](file:///D%3A%5C3GPP%5CRAN1%5C2021%5C2021.01%5CDocs%5CR1-21xxxxx_round0_mimo2c_v000.doc#_Toc61897386)[Proposal 8 In NR Rel-17, introduce a 1-1 associated between a BFD-RS set and a NBI-RS set.](file:///D%3A%5C3GPP%5CRAN1%5C2021%5C2021.01%5CDocs%5CR1-21xxxxx_round0_mimo2c_v000.doc#_Toc61897387)[Proposal 9 When two TCI states are activated for a CORESET, support inclusion of reference signals used as QCL-Type D sources in the two activated TCI states as BFD-RSs in the single BFD-RS set .](file:///D%3A%5C3GPP%5CRAN1%5C2021%5C2021.01%5CDocs%5CR1-21xxxxx_round0_mimo2c_v000.doc#_Toc61897388)[Proposal 10 For BFRQ, support up to one dedicated PUCCH-SR resource in a cell group with two spatial filters associated with the PUCCH-SR resource.](file:///D%3A%5C3GPP%5CRAN1%5C2021%5C2021.01%5CDocs%5CR1-21xxxxx_round0_mimo2c_v000.doc#_Toc61897389) |