**3GPP TSG RAN WG1 #106-e R1-210nnnn**

**e-Meeting, August 16th – 27th, 2021**

Source: Moderator (CATT)

Title: Moderator summary #1 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 in agenda 8.1.2.3, M-TRP simultaneous transmission with multiple Rx panels. Given there are only three meetings left, the summary will focus on essential issues the FL consideres necessary to complete Rel.17, and issues with high company interests. Issues that are optimization in nature will be revisted at a later stage.

1. Beam measurement/reporting

**Action item:** Companies are invited to provide their preferences in **Table I** below.

**Table I**: list of issues and company positions

|  |  |  |
| --- | --- | --- |
| **#** | **Issue and proposals** | **Summary** |
| 1.1 | max # of beams (M) increased beyond 2  * BM reporting Option 1
* BM reporting Option 2
 | Option 1: ZTE (M = 1/2/3/4)No: Option 2: Lenovo/MoMNo: NEC |
| 1.2 | Aperiodic CMR resource configuration * **Alt1**: One resource set list is included in the resource setting to indicate multiple CMR set IDs, and two indexes are included in the corresponding triggering state to indicate two of the multiple CMR set IDs
* **Alt2**: Two resource set lists are included in the resource setting each indicates multiple CMR set IDs, and two indexes are included in the corresponding triggering state each indicating one of the multiple resource set IDs in each resource set list, respectively
 | Alt-1: MediaTek,Alt-2: MedaiTek, CATT |
| 1.3 | SSBRI/CRI ordering in CSI-report * **Alt1**: 1st SSBRI/CRI corresponds to CMR set with smaller set ID, and 2nd SSBRI/CRI corresponds to CMR set with larger set ID
* **Alt2**: 1st SSBRI/CRI corresponds to 1st CMR set in resource setting, and 2nd SSBRI/CRI corresponds to 2nd CMR set in resource setting
* **Alt-3**: 1st SSBRI/CRI corresponds to CMR set with higher RSRP, 2nd SSBRI/CRI corresponds to CMR set with lower RSRP
 | Alt-1: mediaTek, NECAlt-2: MediaTek, CATT, Intel, DOCOMO, QC, NECAlt-3: MediaTek  |
| 1.4 | UCI reduction * Alt-1: Differential reporting across all beam groups in a CSI-report
	+ Including 1-bit indicator of the CMR set associated with the largest RSRP value in all groups
		- NOTE: best beam is assumed in the 1st group
	+ **Alt-1.1**: 1-bit indicating CMR set with higher RSRP value (e.g. 0 indicating 1st SSBRI/CRI from 1st CMR set, 1 indicating 1st SSBRI/CRI from 2nd CMR set); UCI payload partitioning = 7/4 bits for 1st/2nd SSBRI/CRI in first beam group; 4 bits for all beams in other groups;
	+ **Alt-1.2**: 1-bit indicating UCI payload partitioning (e.g. 7/4 bits or 4/7 bits) between 1st/2nd SSBRI/CRI in first beam group; 4 bits in all other groups;
* Alt-2: Differential reporting within each beam group in a CSI-report
	+ For each group, including an 1-bit indicator of CMR set associated with the largest RSRP value in the group
* Alt-2: No UCI reduction
 | Alt-1: HW/HiSilicon, Lenovo/MoM, NEC, OPPO, MediaTek, DOCOMO, vivo * Alt-1.1: MediaTek
* Alt-1.2: NEC

Alt-2: ZTEAlt-3: CATT, QC |
| 1.5 | 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
	+ **Alt-2.1**: whether beams are associated to different Rx filters/panels (Apple, Xiaomi, Ericsson, CATT)
	+ **Alt-2.2**: whether beams are received with spatial multiplexing or diversity ([ ])
	+ **Alt-2.3**: maximum number of supported layer per DL RS in a group (MediaTek)
* Alt-3: Postpone
* Alt-4: Not support
 | Alt-1: LGE, DOCOMO (BM option 1)Alt-2: ZTE, Samsung, Qualcomm, CMCC, MediaTek, Apple, LGE, Xiaomi, Ericsson, CATTAlt-3: Nokia/NSBAlt-4:  |
| 1.6 | gNB indication of Rx panel hypothesis * E.g. whether beam pairs in a group are used for spatial multiplexing or diversity
 | Support: Intel, QCNo:  |
| 1.7 | Support L1-SINR report* support measurement of interference arising from the other beam in the reported beam group
* FFS: IMR resource assumption, e.g.
	+ reuse CMR of other beam in the beam group (LGE)
	+ explicit IMR configuration (TCL/Nokia/NSB), including ZP and/or NZP IMR
 | * Support: ZTE, CATT, Lenovo/MoM, Spreadtrum, Qualcomm, Intel, LGE, Xiaomi, TCL, Nokia/NSB, Sony, ETRI,
* No: OPPO, Apple, 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: ZTE (with group ID and/or panel ID report), OPPO, DOCOMO, Sony
* No: CMCC, Apple, Ericsson, Qualcomm
* Option 3: CATT, Nokia/NSB, vivo
* No: CMCC, Apple, Ericsson, Qualcomm
 |

* 1. Increasing M beyond 2 (issue 1.1)

Observation**:**

* On whether the number of reported beams in a group (M) should be increased beyond 2, at least one company is OK with supporting M > 2 for option 2. For option 1 (which has not been agreed yet), one company proposes to adopt M = 1/2/3/4.

Offline proposal

|  |  |
| --- | --- |
| Company | views |
| Qualcomm | We are fine to support M>2 with UE capability for Option 2. Option 2 itself may be enough to our understanding. |
| NEC | We do not support M > 2 for option 2. 2 CMR sets configuration is agreed for option 2, and M=2 could be enough. To support M>2 with 2 CMR sets we need to address many new issues, e.g., how to determine the number of beams per set, how to report. |
| Apple | We failed to see the use case of M>2. Currently, mTRP only supports 2 TRPs. |

* 1. Aperiodic CMR configuration (issue 1.2)

Observation:

* It was agreed in the last meeting that CMR resource associated with each TRP is represented by a CMR resource set. For periodic/semi-persistent CMR, this should be straightforward as one CMR resource setting comprises two CMR resource sets (each associated with a TRP). For aperioic CMR configuration, one company (MediaTek) proposes two alternatives. In one alternative, one CMR resource setting consists of a list of CMR sets, where an aperiodic triggering state can be associated with two CMR sets in the resource setting. In the other alternative, two CMR set lists are included in the resource setting, and a triggering state is associated with two CMR sets (in two CMR set lists respectively).

Offline proposal

|  |  |
| --- | --- |
| Company | views |
| Qualcomm | Our understanding is that current trigger state can already link to multiple CMR sets. The only missing thing is to clarify each trigger state can trigger two sets simultaneously, which is not allowed today. A new CMR list may not be needed to our understanding. CSI-AssociatedReportConfigInfo ::= SEQUENCE { reportConfigId CSI-ReportConfigId, resourcesForChannel CHOICE { nzp-CSI-RS SEQUENCE { resourceSet INTEGER (1..maxNrofNZP-CSI-RS-ResourceSetsPerConfig), qcl-info SEQUENCE (SIZE(1..maxNrofAP-CSI-RS-ResourcesPerSet)) OF TCI-StateId OPTIONAL -- Cond Aperiodic }, csi-SSB-ResourceSet INTEGER (1..maxNrofCSI-SSB-ResourceSetsPerConfig) }, csi-IM-ResourcesForInterference INTEGER(1..maxNrofCSI-IM-ResourceSetsPerConfig) OPTIONAL, -- Cond CSI-IM-ForInterference nzp-CSI-RS-ResourcesForInterference INTEGER (1..maxNrofNZP-CSI-RS-ResourceSetsPerConfig) OPTIONAL, -- Cond NZP-CSI-RS-ForInterference ...} |
| Apple | We are open to study the issue, but we would like to understand it more. It seems currently one trigger state can be linked to multiple CMR sets, what would be the problem for legacy way？ |

* 1. SSBRI/CRI ordering in CSI-report (issue 1.3)

Observation:

* The ordering of two beams in a reported beam group needs to be defined. Three alternatives are provided in Table I based on company proposals.

Offline proposal

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | For issue 1.3, we support Alt2, which seems the simplest one.  |
| NEC | We see no difference in the possible consequences to adopt Alt1 or Alt2. Thus we can support either one of them. |
| Apple | We support Alt2. |

* 1. UCI reduction scheme (issue 1.4)

Observation:

* Differential reporting has been supported in group-based reporting in earlier NR releases. One open issue from the last meeting is how/whether to support UCI reduction toward M-TRP. Several proposals are captured in Table I.

Offline proposal

* Support differential reporting as a UCI reduction scheme for beam measurement/reporting option 2.
* Details FFS.

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | Support Alt3. We don’t think new bits should be introduced to reduce the payload.  |
| NEC | Firstly, we support the proposal to have differential reporting in general.Secondly, we support Alt-1 in Table 1 #1.4 to have global differential reporting since clearly it has a lower UCI size.Thirdly, we support Alt-1.2 to reflect which set has the highest RSRP reported. To make it clear, we suggest the following changes in red for **Table 1, #1.4, Alt-1.2*** + **Alt-1.2**: 1-bit indicating the mapping position of 7-bit highest RSRP value, e.g., UCI payload partitioning ~~(e.g.~~ 7/4 bits or 4/7 bits~~) between~~ for reporting RSRP values corresponding to 1st/2nd SSBRI/CRI in first beam group; 4 bits in all other groups;

We also notice the relationship between issue 1.3 and 1.4. Naturally, if a pre-defined/fixed mapping order of SSBRI/CRI (e.g., Alt1 or Alt2 of Table 1, #1.3) is supported, Alt-1.2 would be the reasonable solution. |
| Apple | Support the proposal |

* 1. UE panel/antenna related feedback (issue 1.5)

Observation:

* On UE panel/antenna related feedback, two high level alternatives were discussed in the previous meeting with a list of candidates itemized in Table I. One company proposed to delay this discussion until panel-ID related issue in AI 8.1.1. is more stabilized.

Offline proposal

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | Support Alt2, which does not require any panel ID. So no need to correlate with 8.1.1, which is also for UL |
| Apple | Support Alt2. We do not need to wait for 8.1.1 decision since both AIs are based on different BM framework.  |

* 1. gNB indication of UE panel related hypothesis (issue 1.6)

Observation:

* Related to UE indication of panel related information, it is possible that gNB provides indication/configuration of such panel-related hypotheis in CSI-report configuration.

Offline proposal

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | We support the proposal. The intention from gNB is an important input for UE to select the beam(s), e.g. if the purpose is for diversity, UE may report two gNB beams creating the max combine SINR, which may be received by single Rx beam.  |
| Apple | In our view, this should be something like gNB indication of transmission scheme assumption for beam report, and it is better that this is used for CSI report instead of beam report. |

* 1. L1-SINR and interference measurement (issue 1.7)

Observation:

* Aside from already agreed L1-RSRP, whether L1-SINR should be supported remains open. Company views (including possible interference measurement resources and hypothesis) are summarized in Table I.

Offline proposal

* NOTE: The FL recommends to make a decision whether it is supported in RAN1#106-e.

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | Support L1-SINR, which can reflect the cross-beam interference. As clarified in last meeting, the CMR/IMR is measured in TDMed fashion to our understanding, so it is feasible for UE to measure. Suppose UE reports gNB beam 1 and 2 in a group. The CMR and IMR to compute L1-SINR for gNB beam 1 are transmitted by gNB beam 1 and 2, respectively, and are received by UE Rx beam corresponding to gNB beam 1. Similar configuration is applied for computing L1-SINR for gNB beam 2.  |
| Apple | We failed to see performance gain for L1-SINR. It would be challenging to measure inter-beam interference. In addition, this seems to be redundant since there are some enhancement in CSI. |

* 1. Other BM options (issue 1.8)

Observation:

* It is open whether the two remaining options (option 1 and 3) for beam measurement/reporting should be supported in Rel.17. It appears that concerns on both options have not been resolved over the meetings, so the FL proposal is to adopt neither.

Offline proposal

* Do not support beam measurement/feedback option 1 and 3 in Rel.17 for M-TRP simultaneous transmission with multiple UE Rx panels.

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | We slightly prefer no new Option. Option 2 should be enough |
| Apple | OK with the proposal |

1. M-TRP Beam failure recovery

**Action item**: Companies are invited to provide your preferences in **Table II**.

**Table II**: list of issues and company positions

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1 | Simultaneous configuration of cell-specific and TRP-specific BFR in a cell   | Yes: APT/FGI, CMCC, MediaTek, ITRI, TCL, Nokia/NSB, Sony,No : Qualcomm, Intel, DOCOMO, CATT |
| 2.2BFD-RS  | Q1: # of BFD-RS resources per set* Alt1: max value is 2
* Alt2: max value is a UE capability, including possible candidate value of 1

Q2: # total number of BFD-RS resource across two sets is a UE capability  | Q1: * Alt-1: FGI/APT, Convida,
* Alt-2: Qualcomm, Apple, LGE, TCL, vivo, ETRI

Q2: Yes: Qualcomm |
| 2.3BFD-RS | Explicit vs. implicit BFD-RS Q1: Explicit configuration * Each BFD-RS set should be configured with a CORESSETPoolIndex

Q2: Implicit configuration of BFD-RS set k (k=0,1) for M-DCI* Based on X TCI of CORESETs with CORESETPoolIndex = k
* FFS: value of X (determined in spec or UE capability), and TCI selection rule when the number of CORESETs with CORESETPoolIndex = k exceeds X (e.g. reuse RLM RS selection rule)

Q3: Implicit configuration BFD-RS set k for S-DCI, e.g. * Option 1: Based on TCI of CORESETs with CORESETPoolIndex = k; Extend CORESETPoolIndex to S-DCI (for BFD-RS set generation)
* Option 2: From TCI states associated with activated TCI codepoint

Q4: Support 1-to-1 association between BFD-RS set with CORESETPoolIndex | Q1: ZTE, Spreadtrum, Samsung, Fujitsu, FGI/APT, Qualcomm, CMCC, MediaTek, LGE, ITRI, Convida, Ericsson, Nokia/NSB, vivo, Sony, ETRI, NECNO: OPPO Q2: ZTE, Lenovo/MoM, Samsung, Fujitsu, OPPO, FGI/APT, Qualcomm, CMCC, MediaTek, AT&T, LGE, Xiaomi, ITRI, Convida, Ericsson, Nokia/NSB, Nokia/NSB, vivo, ETRI, NECQ3: HW/HiSilicon, Lenovo/MoM, Samsung, Fujitsu, MediaTek, CATT, Intel, AT&T, CMCC, LGE, Xiaomi, ITRI, Sony, Nokia/NSB (option 2), QC, NECNo: EricssonQ4: MediaTek, CATT (if explicit BFD-RS is adopted), OPPO, No: LGE  |
| 2.4BFD-RS | Introduce MAC-CE for updating explicit BFD-RS set | Support: CATT, ZTE |
| 2.5NBI-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: CATT, Intel, Apple, ITRI, ETRI,Alt-2: ZTE, Fujitsu, OPPO (via CORESETPoolindex), Qualcomm, CMCC (via CORESETPoolIndex), Alt-3: Convida, Nokia/NSB,  |
| 2.6PUCCH-SR resource | PUCCH-SR resource selection rule for LRR feedback* Alt 2.5.2 A:
* On PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, there is no consensus to adopt alt-1 or alt-2. PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 B:
* On the PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, and at most one BFD RS set fails per CC, adopt alt 2 (e.g. association to failed BFD-RS set) if all failed BFD RS sets cross CCs are associated with the same PUCCH SR resource, else PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 C:
* On the PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, and at most one BFD RS set fails per CC, adopt alt 1 (e.g. association to non-failed BFD-RS set) if all failed BFD RS sets cross CCs are associated with the same PUCCH SR resource, else PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 D:
* Revert the past agreement on supporting configuration of up to 2 PUCCH-SR resources. A UE can be configured up to 1 PUCCH-SR resource in a cell group.
 | Alt-2.5.2 A: FGI/APT, Apple, LGE, TCLAlt-2.5.2 B: ZTE (SCell), InterDigital, Spreadtrum, CATT, Fujitsu, Qualcomm, Xiaomi, ETRIAlt-2.5.2 C: ZTE (SpCell), Samsung, NEC, CMCC, Xiaomi, CATT, Nokia/NSBAlt-2.5.2 D: Convida, Ericsson |
| 2.7PUCCH-SR resource | Whether PUCCH-SR resource can have 1 or 2 activated spatial filtersAlt-1: Only 1 Alt-2: up to 2; diversity (e.g. AI 8.1.2.1) when 2 spaial filters are activatedAlt-3: up to 2; filter selection when 2 spatial filters are activatedAlt-4: up to 2; transmission method undefined when 2 spatial filters are activated | Alt-1: Spreadtrum, Alt.2: CATTAlt-3: Qualcomm, Intel, Alt-4: APT/FGI, Apple, Convida, |
| 2.8MAC-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: HW/HiSilicon, CATT, MediaTek (2-bit bitmap), LGE, TCL, Nokia/NSB, QCAlt-2: ZTE(?)Alt-3:  |
| 2.9MAC-CE | Indication of failed TRP in MAC-CE * Alt-1: failed BFD-RS set ID
* Alt-2: failed CORESETPoolIndex
 | Alt-1: HW/HiSilicon, LGE, CATT. TCL, Nokia/NSB, vivo, QCAlt-2: ZTE, OPPO, Sony, ETRI, |
| 2.10MAC-CE | Q1: Whether 1 or 2 TRP receives new beam report for each SCell* Alt-1: resource index representing identified new beam (if found) for only 1 failed TRP, irrespective of 1 or 2 TRP failure
* Alt-2: resource index representing identified new beam (if found) for each failed TRP

Q2: format of new beam * Alt-1: separate encoding (e.g. log2(N1) bit for TRP1, log2 (N2) bit for TRP2, where N1/N2 are # NBI-RS resources in set 1 and 2)
* Alt-2: joint encoding
 | Q1: * Alt-1: DOCOMO
* Alt-2: HW/HiSilicon, DOCOMO, CATT, QC

Q2: * Alt-1: CATT, QC
* Alt-2: Convida
 |
| 2.11Beam/power update | UE assumption of DL QCL-typeD and UL filter/power control after receiving gNB responseQ1: 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: Support beam update for PDCCH * Introduce association between BFD-RS set and CORESETs

Q4: Support beam/power update for PUCCH* Introduce association between PUCCH and TRP, e.g. through BFD-RS set ID, CORESETPoolIndex, etc.

Q5: Support beam/power update for all data/control channels | Q1: Support: CATT, QCQ2: Support: CATT, QCQ3: Support: ZTE, Lenovo/MoM, Spreadtrum, Fujitsu, OPPO, MediaTek, CATT, Sony, ETRI, QCNo: Q4: Support: ZTE, Lenovo/MoM, Spreadtrum, Fujitsu, APT/FGI, Qualcomm, DOCOMO, Sony, ETRINo: OPPOQ5: Support: Apple No:  |
| 2.12RACH based fallback | Support CBRA based fallback on SpCell as a result of per-TRP beam failure, conditions FFS.  | Support: Hw/HiSilicon, ZTE, CATT, NEC, FGI/APT, Intel, LGE, Asustek, Nokia/NSB, OPPO, Xiaomi, Asustek, QCNo:  |
| 2.13RACH based fallback | Support CFRA based fallback  | Support: AsustekNo:  |

* 1. Simultaneous configuration of cell-specific and TRP-specifc BFR in the same CC (issue 2.1)

Observation:

* It remains open whether cell-specific and TRP-specific BFR can be simultaneously configurd in the same cell. To decide on this issue, a clear definition of “cell-specific” vs. “TRP-specific” BFR is needed.
* It should be clear that TRP-specific BFR requires two BFD-RS sets configured in a CC, to allow per-TRP failure detection.
* Cell-specific BFR has two interpretations.
	+ Interpretation 1: refers to RACH-based fall back scheme (e.g. Rel.15/16).
	+ Interpratation 2: refers to a case where one BFD-RS is configured in a CC. Simultaneous configuration of “cell-specific” and “TRP-specific” BFR can then be interpretated as 3 BFD-RS in a CC corresponding to two seprate BFR procedures, each associated to 1 and 2 BFD-RS sets.
	+ The FL’s understanding is that the intended discussion is to clarify the use case of interpretation 2. Interpration 1 (e.g. interaction with RACH-based fallback) is discussed in a separate sub-agenda.

Offline definition (for purpose of facilitating discussion)

* Simultaneous configuration of cell-specific and TRP-specific BFR in the same CC refers to the configuration of 3 BFD-RS sets in a CC, where cell-specific and TRP-specific BFR are associated to 1 and 2 BFD-RS sets, respectively.

Action item:

* Please comment if the offline definition above is agreeable.
* Please share your views on issue 2.1 in Table II.

Offline proposal:

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | We are fine for the above definition. We don’t support simultaneous configuration.  |
| NEC | As BFD RS set(s) are configured/assumed per BWP, so we think it’s better to be discussed on BWP level, and the issues are:1. Whether simultaneous configuration of cell-specific and TRP-specific BFR supported on different BWPs of a same CC.

It seems this is related to the offline definition (Interpretation 2)? For this issue, we think it should be supported, as there may be a case that in one CC, one BWP configured with only one TRP, and another one BWP configured with two TRPs, so cell-specific BFR and TRP-specific BFR should be supported respectively.1. Whether simultaneous configuration of cell-specific and TRP-specific BFR supported on a same BWP of a CC

It seems this is related to Interpretation 1 (RACH-based fall back). We think this needs to be supported, when two TRPs failed. |
| Apple | Regarding the definition, we think we need clarification as follows：* Simultaneous configuration of cell-specific and TRP-specific BFR in the same CC refers to the configuration of 3 BFD-RS sets in a CC, where cell-specific and TRP-specific BFR are associated to 1 and 2 BFD-RS sets, respectively.
	+ Note: The BFD RS should be QCLed with DMRS of PDCCH in the same CC
	+ Note: One BFD RS can be configured within both cell-specific BFD RS set and TRP-specific BFD RS set
 |

* 1. BFD-RS resource set size (issue 2.2)

Observation:

* Toward the end of last meeting, the majority of companies were willing to support a UE capability on the maximum number of BFD-RS resources per set. The FL recommends to agree on this.

Offline proposal

* The maximum number of BFD-RS resources per set is a UE capability, including a possible candidate value of 1 in Rel.17.
	+ FFS: whether the maximum total number of BFD-RS resources across two BFD-RS sets is a UE capability.

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | Support the proposal.  |
| NEC | Support the proposal. |
| Apple | Support the proposal |

* 1. BFD-RS set determination (issue 2.3)

Observation:

* Explicit configuration:
	+ the majority of companies support this operation, except one company. Given that QCL-typeD of TCI states may correspond to aperidic RS, and that beam failure detection should be based on periodic/semi-persistent RS, it appears that explicition configuration is required in Rel.17.
* Implicit configuration for M-DCI:
	+ Majority of companies support this operation, with no concern raised, where BFD-RS set k (k = 1, 2) is based on CORESETs with CORESETPoolIndex = k.
* Implicit configuration for S-DCI:
	+ A large number of companies (including operators) support this operation, with a small number of companies with lingering question on its need, which was clarified by supporting companies in the past.
	+ Given the majority view, the FL wishes to check if the concerned companies would oppose this functionality.

Offline proposal

*

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | We support implicit config for s-DCI. Similar to m-DCI, s-DCI can also send PDCCH from both TRPs for diversity. So the use case is as important as m-DCI. Introducing a new TRP ID should be a simple way to our understanding.  |
| NEC | We support all the configurations, with more input in above table. |
| Apple | We support to reuse the approach as PL-RS configuration to configure BFD RS as follows：* Two candidate BFD RS sets can be configured by RRC
* In each TCI state, gNB can optionally configure the BFD RS index
	+ If the BFD RS is not provided, the RS for QCL indication in the TCI state is used for BFD
 |

* 1. BFD-RS set update by MAC-CE (issue 2.4)

Observation:

* Two companies support update of BFD-RS sets by MAC-CE, which is currently only possible by RRC. Among these two companies, one company supports this functionality only if implicit BFD-RS is not supported (for at least S-DCI).

Offline proposal

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | We believe implicit BFD RS is needed and can solve this issue. Even for explicit BFD RS, our understanding based on the spec is that UE will select the BFD RS with same QCL as the new CORESET TCI from the RRC configured candidate BFD RSs.  |
| Apple | With our proposal in 3.3, this issue would not exist. |

* 1. NBI-RS set association to BFD-RS set (issue 2.5)

Observation:

* It has been agreed there is a 1-to-1 association between BFD-RS set and NBI-RS set. Three options on BFD-RS/NBI-RS set association are pending a down-selection.

Offline proposal

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | Support Alt2. Both BFD-RS set and NBI-RS set are linked to the TRP ID.  |
| Apple | Support Alt1. One question to Alt2, is it configured by RRC or MAC CE? If it is configured by RRC, there seems to be no difference compared to Alt1. |

* 1. PUCCH-SR resource selection (issue 2.6)

Observation:

* In case of one TRP failure (one SCell and/or SpCell), whether/how to perform PUCCH-SR resource selection for LRR has been debated in several meetings. Four candidate options were captured in Chairman’s notes for down-selection in RAN1#106-e.
* An offline email discussion was conducted between RAN1#105-e, where another two alternatives were discussed.

|  |
| --- |
| *Offline Proposal1 in email* * *For PUCCH-SR resource selection for TRP-specific BFR,*
* *Support to configure an association between a TRP (e.g., BFD-RS set) on SpCell and a PUCCH-SR resource on SpCell.*

*Offiline Proposal2 in email* * *When 2 PUCCH-SR resources are configured on SpCell, if SR for BFR is triggered (e.g., by any TRP/cell failure in the cell group), the two PUCCH-SR resources are transmitted.*
 |

* The FL does not intend to spend online time on this, unless concensus can be reached offline. Note that if concensus is not possible, option A is the default assumption.

Offline proposal

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | Support offline proposal 1. Suppose UE sends two PUCCH-SRs, gNB may need to determine which one is stronger to send back response. This may require ideal BH and additional coordination between 2 TRPs. If gNB simply sends responses from both TRPs after receiving the 2 PUCCH-SRs, this unnecessarily wastes UL resource and we need to further clarify beam resetting time is based on which response. If gNB sends response only from one randomly selected TRP, the response may not be reliable if the selected TRP is the failed one. So UE only sending PUCCH-SR to the working TRP should be the most efficient way to avoid unnecessary transmissions.  |
| NEC | In our understanding, PUCCH-SR resource selection is actually related to BFR on SpCell. If two TRPs configured for SpCell, and one TRP failed, either Alt 1 or Alt 2 can be applied for PUCCH-SR resource selection, and if no TRP failed on SpCell, any one of the two PUCCH-SR resource can be selected. |
| Apple | We think up to UE implementation could be the best way, which is like RACH resource selection for CBRA.  |

* 1. PUCCH-SR spatial filter (issue 2.7)

Observation:

* 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 filters. 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.
* The FL believes this is not the most essential issue for Rel.17 completion. Unless consensus can be reached, the FL proposes to postpone this issue to later stage.

Offline proposal

* Postpone to future meetings.

|  |  |
| --- | --- |
| Company | Views |
|  |  |

* 1. BFRA MAC-CE content (issue 2.8, 2.9, 2.10)

Observation: There are three main issues on MAC-CE design

* Whether one or two MAC-CEs are used for BFRQ report.
* What information is conveyed in the MAC-CE
* Format of information in the MAC-CE

Offline proposal

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | One MAC-CE is enough. Failed BFD-RS set ID should be included. CORESETPoolIndex only works for m-DCI. Support Alt2, the same MAC-CE can also indicate new beam per TRP when both TRPs fail |
| Apple | We support one MAC CE.We think the failed BFD RS set ID should be reported.Detail MAC CE format can be handled by RAN2, and we can decide what information is needed. |

* 1. QCl/Spatial filter and power update after gNB response (issue 2.11)

Observation:

* A large number of companies support QCL assumption update for CORESETs that have been identified as failed and for which a new beam has been reported. For implicit BFD-RS determination, applicable CORESETs can be derived from the assoction of CORESETs to BFD-RS and NBI-RS sets. For explicit BFD-RS determination, association of BFD-RS sets to applicable CORESETs have been proposed, e.g. via CORESETPoolIndex.
* A few company support spatial filter and power control parameter update for PUCCH. Association between applicable PUCCH resources and new beam is needed in this case, e.g. via association between PUCCH resources and CORESETPoolIndex.
* One company supports QCL/spatial filter and power control parameter update for all DL/UL data/control channels, across CCs in a band.

Offline proposal

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | Our views are added to the list.  |
| NEC | We are fine with the discussion when one TRP failed, and in case of two TRPs failed, we think it should depend on the output of 3.1 and 3.10 |
| Apple | Currently the number of active TCI/QCL is limited from commercial UE, if we only recover the control channel beam, one possible outcome is that gNB has to use fallback mode, e.g. default PDSCH beam and DCI format 0\_0 to schedule data channel. |

* 1. RACH-based fallback (issue 2.12, 2.13)

Observation:

* Issue 2.12 (CBRA): A large number of companies support CBRA-based fallback on SpCell *as a result of* per-TRP beam failure detection. Several triggering conditions are proposed.
* Issue 2.13 (CFRA): One company proposes CFRA-based fallback.

Offline proposal

* CBRA-based transmission can be triggered on SpCell as a result of beam failure detection for per-TRP BFR
	+ FFS: exact triggering condition
* FFS: CFRA based transmission on SpCell

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | Support the offline proposal. CBRA can be triggered if both TRPs fail on SpCell.  |
| NEC | Support the proposal. |
| Apple | Support the proposal. At least when no PUCCH-SR configured, CBRA should be the fallback mode. |

1. Simultaneous reception of signals with different QCL-typeD assumption

**Table III**: list of issues and company positions

|  |  |  |
| --- | --- | --- |
| **#** | **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: Apple, QC Concern: Alt2: Support: AppleConcern;  |
| 3.2 | Type of combinations to be enhanced: Case 1: PDCCH+PDCCHCase 2: PDCCH+PDSCHCase 3: CSI-RS + CSI-RS | Case 1: Support: Lenovo, MediaTekConcern: Case 2: Support: MediaTekConcern: Case 3: Support: LenovoConcern:  |
| 3.3 | Study both S-DCI and M-DCI | Support: DOCOMOConcern:  |

Observation:

Offline proposal:

|  |  |
| --- | --- |
| Company | Views |
| Qualcomm | Our preference is added to the list |

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. RAN1#105-e

**Agreement**

For CMR configuration for option 2, adopt

* Alt-1: “set”

**Agreement**

The bitwidth of each SSBRI/CRI is determined based on the number of SSB/CSI-RS resources in the associated CMR resource set

* FFS: specify the association between SSBRIs/CRIs in a reported group and CMR resource sets

**Agreement**

* For beam measurement/reporting option 2, the maximum number of beam groups in a single CSI-report is a UE capability and may take value from Nmax = {1,2,3,4} in Rel.17.
	+ FFS: If UCI payload reduction for Nmax>=2 is needed and if so, how
* The number of beam groups (N) reported in a single CSI-report
	+ Alt1: The value of N is configured by RRC signalling

**Agreement**

Select one of the following alternatives with possible modification in RAN1#106-e

* Alt 2.5.2 A:
	+ On PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, there is no consensus to adopt alt-1 or alt-2. PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 B:
	+ On the PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, and at most one BFD RS set fails per CC, adopt alt 2 if all failed BFD RS sets cross CCs are associated with the same PUCCH SR resource, else PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 C:
	+ On the PUCCH-SR resource selection rule when SR is triggered and 2 PUCCH-SR resources are configured, and at most one BFD RS set fails per CC, adopt alt 1 if all failed BFD RS sets cross CCs are associated with the same PUCCH SR resource, else PUCCH-SR resource selection is up to UE implementation.
* Alt 2.5.2 D:
	+ Revert the past agreement on supporting configuration of up to 2 PUCCH-SR resources. A UE can be configured up to 1 PUCCH-SR resource in a cell group.
1. Reference

|  |  |  |
| --- | --- | --- |
| [R1-2106791](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106791.zip) | Enhancements on beam management for multi-TRP | Sony |
| [R1-2106868](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106868.zip) | Enhancements on beam management for multi-TRP | Samsung |
| [R1-2106938](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2106938.zip) | Enhancements on beam reporting and beam failure recovery for multi-TRP | CATT |
| [R1-2107031](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107031.zip) | Enhancements on beam management for multi-TRP | Fujitsu |
| [R1-2107081](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107081.zip) | Beam management for simultaneous multi-TRP transmission with multi-panel reception | FUTUREWEI |
| [R1-2107145](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107145.zip) | Discussion on beam management for multi-TRP | NEC |
| [R1-2107206](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107206.zip) | Enhancements on beam management for multi-TRP | OPPO |
| [R1-2107298](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107298.zip) | Discussion of enhancements on beam management for multi-TRP | FGI, Asia Pacific Telecom |
| [R1-2107326](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107326.zip) | Enhancements on beam management for multi-TRP | Qualcomm Incorporated |
| [R1-2107393](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107393.zip) | Enhancements on beam management for multi-TRP | CMCC |
| [R1-2107470](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107470.zip) | Enhancements on beam management for multi-TRP | ETRI |
| [R1-2107487](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107487.zip) | Enhancement on beam management for multi-TRP | MediaTek Inc. |
| [R1-2107573](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107573.zip) | Multi-TRP enhancements for beam management | Intel Corporation |
| [R1-2107690](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107690.zip) | Beam Management Enhancements for multi-TRP | AT&T |
| [R1-2107721](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107721.zip) | Views on Rel-17 multi-TRP BM enhancement | Apple |
| [R1-2107817](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107817.zip) | Enhancements on beam management for multi-TRP | LG Electronics |
| [R1-2107841](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107841.zip) | Discussion on beam management for MTRP | NTT DOCOMO, INC. |
| [R1-2107896](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2107896.zip) | Enhancement on beam management for Multi-TRP | Xiaomi |
| [R1-2108009](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108009.zip) | Discussion on beam management for multi-TRP | ITRI |
| [R1-2108021](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108021.zip) | On Multi-TRP BFR | Convida Wireless |
| [R1-2108030](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108030.zip) | Discussion on beam management for multi-TRP | ASUSTEK COMPUTER (SHANGHAI) |
| [R1-2108044](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108044.zip) | Enhancements on beam management for multi-TRP | TCL Communication Ltd. |
| [R1-2108045](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108045.zip) | On beam management enhancements for multi-TRP | Ericsson |
| [R1-2108055](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_106-e/Docs/R1-2108055.zip) | Enhancements on Beam Management for Multi-TRP/Panel Transmission | Nokia, Nokia Shanghai Bell |