**3GPP TSG-RAN WG4 Meeting # 109 R4-2318162**

**Chicago, US, November 13 – November 17, 2023**

**Agenda item:** 8.7.5

**Source:** Moderator (vivo)

**Title:** Topic summary for [109][206] FR2\_multiRx\_part1

**Document for:** Information

# Introduction

This email discussion summary covers following agenda for FR2 multi-Rx chain DL reception WI.

8.7.2 RRM core requirements for simultaneous DL reception from different directions [NR\_FR2\_multiRX\_DL-Core]

8.7.2.1 General aspects

8.7.2.3 RLM and BFD/CBD requirements

8.7.2.4 Scheduling/measurement restrictions

8.7.3 RRM performance requirements [NR\_FR2\_multiRX\_DL-Perf]

# Topic #1: General aspect

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318499 | MediaTek inc. | **Proposal 1: Scheduling/measurement restriction and dual TCI state switch are merged into a single FG.****Proposal 2: For fast beam sweeping, gNB does not need to know the reduced sweeping factor.****Proposal 3: Consider Table 2 when introducing UE feature list for mRx WI.** |
| R4-2318689 | Apple | **Proposal 1: In the follow-up LS to RAN2, RAN4 can share RAN4-specified UE capabilities with RAN2, while asking RAN1 to share RAN1-specified UE capabilities that depend on multi-RX operation at UE side.****Proposal 2: When the side conditions are violated, the corresponding requirement is not applicable, and no UE behavior needs to be specified.** **Proposal 3: It is proposed to specify two UE capabilities as in Table 1.** |
| R4-2318690 | Apple | **[draft] LS on associated UE capabilities for UE indication of FR2 multi-RX operation** |
| R4-2318851 | xiaomi | **Proposal 1: Suggest not to use capability as indication, as the Multi-RX indication may be dynamic.****Proposal 2: No need to define new additional UE capability to support simultaneous reception of RS+data or RS+RS.****Proposal 3: No UE behavior needs to be defined when Multi-RX condition becomes violated.** |
| R4-2319041 | vivo | **Proposal 1: When the side conditions are changed with a transition between multi-Rx operation and no multi-Rx operation, the corresponding multi-Rx requirement is not applicable, and no UE behavior needs to be defined.****Proposal 2: A new UE capability of supporting simultaneous reception of RS and data from different directions with different QCL type D RSs for enhanced L1 measurements for multi-Rx is introduced.** **Proposal 3: A new UE capability of supporting simultaneous reception of RS and RS from different directions with different QCL type D RSs for enhanced L1 measurements for multi-Rx is introduced, if measurement restriction is enhanced for multi-Rx.****Proposal 4: No UE capability is introduced for additional delay in dual TCI state switch.****Proposal 5: UE feature for Rel-18 FR2 multi-Rx DL reception is as in Table 1** **for NR\_FR2\_multiRX\_DL.** |
| R4-2319272 | Nokia, Nokia Shanghai Bell | [**Proposal 1: To support Rel-18 multi-Rx DL simultaneous reception of data+measurement and measurement+measurement, an additional UE capability needs to be defined.**](#_Toc149897349)[**Proposal 2: For the new UE indication on UE preference on not supporting simultaneous reception with different QCL-typeD, only the following related UE capabilities in FR2-1 are to be involved:**](#_Toc149897350)* + **simultaneousReceptionDiffTypeD-r16**
	+ **UE capabilities to be introduced in Rel-18 NR\_FR2\_multiRX\_DL which will be finalized in RAN4 feature list.**
 |
| R4-2319358 | Huawei, HiSilicon | **Observation 1: The intention of the indication is to indicate that UE’s preference on temporarily not support simultaneous reception with different QCL TypeD instead of number of panels since “panel” which is transparent to NW and specification.** **Observation 2: The exact UE capabilities related to simultaneous reception with different QCL which will be impacted by this new indication shall be defined to avoid ambiguities.****Proposal 1: For the new UE indication on UE preference on not supporting simultaneous reception with different QCL-typeD, following related UE capabilities in FR2-1 are identified to be involved:*** **simultaneousReceptionDiffTypeD-r16**
* **defaultQCL-PerCORESETPoolIndex-r16**
* **defaultQCL-TwoTCI-r16**
* **mTRP-PDCCH-TwoQCL-TypeD-r17**
* **sfn-SchemeA-r17**
* **sfn-SchemeA-DynamicSwitching-r17**
* **sfn-SchemeA-PDCCH-only-r17**
* **sfn-SchemeA-PDSCH-only-r17**
* **sfn-SchemeB-r17**
* **sfn-SchemeB-DynamicSwitching-r17**
* **sfn-SchemeB-PDSCH-only-r17**
* **sfn-SimulTwoTCI-AcrossMultiCC-r17**
* **sfn-QCL-TypeD-Collision-twoTCI-r17**
* **UE capabilities introduced in Rel-18 NR\_FR2\_multiRX\_DL which will be finalized in RAN4 feature list.**

**Proposal 2: RAN4 to send LS to RAN1/2 to inform the involved UE capabilities related to the new UE indication on UE preference on not supporting simultaneous reception with different QCL-typeD****Proposal 3: Introduce UE feature list for NR\_FR2\_multiRX\_DL as in Table I.** |
| R4-2319463 | OPPO | **Proposal 1: When the side conditions are violated, the corresponding requirement is not applicable, and/or no UE behavior needs to be defined.****Proposal 2: Define the support of simultaneous reception of RS+data or RS+RS on overlapping OFDM symbols as component of the feature group of multi-Rx DL simultaneous reception, without separate or additional UE capabilities.** |
| R4-2319724 | Samsung | **Proposal 1: RAN4 to define new additional UE capabilities to support simultaneous reception of RS+RS and RS+data, separately.*** **Consider the existing UE feature 16-2c as (one of) the prerequisites**

**Proposal 2:** * **There is no need to consider additional delay in dual TCI state switching for multi-Rx**
* **No UE capability is introduced for additional delay in dual TCI state switch**

**Proposal 3: For the applicability scope of the new UE feature (s),** * **If the feature(s) to be defined covers all power classes, the PC6 should be excluded.**
* **If the feature(s) to be defined only applicable for PC3, the PC3 information should be highlighted as the applicability scope**

**Proposal 4: For the Components of the new UE feature (s),*** **Suggest to take “Support of enhanced RF requirement to support UEs with simultaneous DL reception with two different QCL TypeD RSs” as (one of) the components of the new feature (s) (X-1 and X-2).**

**Proposal 5: For the prerequisite feature groups of the new UE feature (s),*** **Suggest to take 16-2c, 23-5-1, 16-2a and/or 16-2b-0 as the prerequisite feature groups of the new feature (X-1 and/or X-2).**
 |
| R4-2320424 | ZTE Corporation | **Proposal 1: When the condition of multi-Rx becomes violated during measurement, at least UE can continue the on-going L1 measurement.** **Proposal 2: When the condition of multi-Rx becomes violated during measurement, the measurement/scheduling restriction relaxation is not allowed any more.****Proposal 3: When the condition of multi-Rx becomes violated during measurement, whether the requirements of L1 measurement period should be relaxed, depending on the final identified L1 measurement period requirements. If fast beam sweeping is applied during L1 measurement, then the condition and implementation of fast beam sweeping would impact the decision.****Proposal 4: Introducing two individual UE capabilities for the supporting of simultaneous L1 RS+L1 RS and L1 RS+data respectively.** |
| R4-2320461 | Ericsson | **Proposal 1 (QCL D+A/C): Scenarios where QCL type D is configured in combination with QCL type A/C are not precluded in the requirements for multi-rx operation.** * **FFS whether or how this needs to be captured in TS 38.133.**

**Proposal 2 (capability/feature list): Based on earlier RAN4 agreements, fast beam sweeping is an optional sub-feature and thus can be marked as “optional with capability signalling”.****Proposal 3 (capability/feature list): All UEs capable of multi-rx feature shall also be capable of:*** **Simultaneous reception of CSI-RSs with different QCL Type-D,**
* **Simultaneous reception of CSI-RS and PDCCH or PDSCH with different QCL Type-D, and**
* **Dual TCI switching,**

**which can be marked as “mandatory with capability signalling”.****Proposal 4 (capability/feature list): Based on earlier RAN4 agreements, the multi-rx requirements are limited to PCell and FR2-1 only and therefore could be signalled “per UE”.****Proposal 5 (capability/feature list): Based on earlier RAN4 agreements, “FR2-1 only” should be stated in the column “Need of FR1/FR2 differentiation”.** |

*The moderator can suggest a limited number of papers which could be presented.*

## Open issues summary

*Before f2f meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-2: RRM requirements impact

*Sub-topic description:*

*Open issues and candidate options before f2f meeting:*

**Issue 1-2-5: Indication of multi-Rx operation**

* Proposals
	+ Option 1: (Huawei)
		- For the new UE indication on UE preference on not supporting simultaneous reception with different QCL-typeD, following related UE capabilities in FR2-1 are identified to be involved:
			* simultaneousReceptionDiffTypeD-r16
			* defaultQCL-PerCORESETPoolIndex-r16
			* defaultQCL-TwoTCI-r16
			* mTRP-PDCCH-TwoQCL-TypeD-r17
			* sfn-SchemeA-r17
			* sfn-SchemeA-DynamicSwitching-r17
			* sfn-SchemeA-PDCCH-only-r17
			* sfn-SchemeA-PDSCH-only-r17
			* sfn-SchemeB-r17
			* sfn-SchemeB-DynamicSwitching-r17
			* sfn-SchemeB-PDSCH-only-r17
			* sfn-SimulTwoTCI-AcrossMultiCC-r17
			* sfn-QCL-TypeD-Collision-twoTCI-r17
			* UE capabilities introduced in Rel-18 NR\_FR2\_multiRX\_DL which will be finalized in RAN4 feature list.
		- RAN4 to send LS to RAN1/2 to inform the involved UE capabilities related to the new UE indication on UE preference on not supporting simultaneous reception with different QCL-typeD
	+ Option 2: (Apple)
		- With UE indication of multi-RX operation, it is necessary for the network to know which UE capabilities will not be supported by the UE when the UE indicates its fallback to single RX operation
		- In the follow-up LS to RAN2, RAN4 can share RAN4-specified UE capabilities with RAN2, while asking RAN1 to share RAN1-specified UE capabilities that depend on multi-RX operation at UE side.
	+ Option 3: (Nokia)
		- For the new UE indication on UE preference on not supporting simultaneous reception with different QCL-typeD, only the following related UE capabilities in FR2-1 are to be involved:
			* simultaneousReceptionDiffTypeD-r16
			* UE capabilities to be introduced in Rel-18 NR\_FR2\_multiRX\_DL which will be finalized in RAN4 feature list.
	+ Option 4: (Xiaomi)
		- Not to use capability as indication, as the Multi-RX indication may be dynamic.
* Recommended WF
	+ Further discuss.

### Sub-topic 1-3: Applicability and conditions

**Issue 1-3-5: UE behaviour when a condition becomes violated during a measurement**

* Proposals
	+ Option 1a: (vivo, Apple, Xiaomi, OPPO)
		- When the side conditions are changed with a transition between multi-Rx operation and no multi-Rx operation, the corresponding multi-Rx requirement is not applicable, and no UE behavior needs to be defined.
	+ Option 2: (ZTE)
		- When the condition of multi-Rx becomes violated during measurement, at least UE can continue the on-going L1 measurement.
		- When the condition of multi-Rx becomes violated during measurement, the measurement/scheduling restriction relaxation is not allowed any more.
		- When the condition of multi-Rx becomes violated during measurement, whether the requirements of L1 measurement period should be relaxed, depending on the final identified L1 measurement period requirements. If fast beam sweeping is applied during L1 measurement, then the condition and implementation of fast beam sweeping would impact the decision.
* Recommended WF
	+ Further discuss

### Sub-topic 1-4: UE feature

**Issue 1-4-4: UE capability for simultaneous reception with different QCL typeD for L1 measurements**

* Proposals
	+ Option 1: (vivo, Huawei, Samsung, ZTE)
		- RAN4 to define new additional UE capabilities to support simultaneous reception of RS+RS and RS+data, separately.
			* A new UE capability of supporting simultaneous reception of RS and data from different directions with different QCL type D RSs for enhanced L1 measurements for multi-Rx is introduced.
			* A new UE capability of supporting simultaneous reception of RS and RS from different directions with different QCL type D RSs for enhanced L1 measurements for multi-Rx is introduced, if measurement restriction is enhanced for multi-Rx.
	+ Option 2a: (MTK, Ericsson)
		- Scheduling/measurement restriction and dual TCI state switch are merged into a single FG.
	+ Option 2b: (Nokia, Apple)
		- To support Rel-18 multi-Rx DL simultaneous reception of data + measurement and measurement + measurement, an additional UE capability needs to be defined.
	+ Option 3: (Xiaomi)
		- No need to define new additional UE capability to support simultaneous reception of RS+data or RS+RS.
	+ Option 3a: (OPPO)
		- Define the support of simultaneous reception of RS+data or RS+RS on overlapping OFDM symbols as component of the feature group of multi-Rx DL simultaneous reception, without separate or additional UE capabilities.

Recommended WF

* + Further discuss.

**Issue 1-4-4a: Power class for new UE capability for simultaneous reception with different QCL typeD for L1 measurements**

* Proposals
	+ Option 1:
		- All power classes except PC6
	+ Option 2
		- PC3 only.
* Recommended WF
	+ Further discuss.

**Issue 1-4-4b: Prerequisite features for new UE capability for simultaneous reception with different QCL typeD for L1 measurements**

* Proposals
	+ Option 1: (vivo, Huawei, MTK)
		- 16-2c
	+ Option 2: (Apple)
		- 16-2c, [2-29a].
	+ Option 3: (Samsung)
		- 16-2c, 23-5-1, 16-2a and/or 16-2b-0.
* Recommended WF
	+ Further discuss.

**Issue 1-4-4c: Frequency range for new UE capability for simultaneous reception with different QCL typeD for L1 measurements**

* Proposals
	+ Option 1:
		- FR2 only.
	+ Option 2:
		- FR2-1 only.
* Recommended WF
	+ Agree on option 2.

**Issue 1-4-4c: Reporting granularity for new UE capability for simultaneous reception with different QCL typeD for L1 measurements**

* Proposals
	+ Option 1: (vivo, Huawei, MTK)
		- Per band.
	+ Option 2: (Apple)
		- Per FSPC.
	+ Option 3: (Ericsson)
		- Per UE.
* Recommended WF
	+ Further discuss.

**Issue 1-4-6: UE feature list**

* Proposals
	+ Option 1: (vivo, Huawei)
		- UE feature for Rel-18 FR2 multi-Rx DL reception is as in Table 1 for NR\_FR2\_multiRX\_DL.
	+ Option 2: (MTK, OPPO)
		- Consider Table 2 when introducing UE feature list for mRx WI.
	+ Option 3: (Apple)
		- It is proposed to specify two UE capabilities as in Table 3.

Table 1:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 30. NR\_FR2\_multiRX\_DL | 30-1 | Simultaneous reception of NR PDCCH/PDSCH overlapping with layer 1 RS with different QCL Type-D | Supports simultaneous reception of PDCCH/PDSCH with different QCL Type-D layer 1 RS for measurement on overlapping OFDM symbols. | 16-2c | Yes | N/A |  | Per band | N/A | FR2 only |  |  | Optional with capability signalling |
| 30. NR\_FR2\_multiRX\_DL | 30-2 | Simultaneous measurement of layer 1 RS overlapping with another layer 1 RS with different QCL Type-D | Supports Simultaneous measurement of layer 1 RS overlapping with another layer 1 RS with different QCL Type-D on overlapping OFDM symbol(s). | 16-2c | Yes | N/A |  | Per band | N/A | FR2 only |  |  | Optional with capability signalling |
| 30. NR\_FR2\_multiRX\_DL | 30-3 | Fast beam sweeping | Supports beam sweeping factor reduction for SSB-based layer 1 measurement. |  | No | N/A |  | Per band | N/A | FR2 only |  | Candidate values for Component 2: {2,4,6} for FR2-1 | Optional with capability signalling |

Table 2:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 30. NR\_FR2\_multiRX\_DL | 30-1 | Support of requirements for multiRx\_DL | * Supports simultaneous reception of PDCCH/PDSCH and RS for L1 measurement with different QCL Type-D on overlapping OFDM symbols, and
* Supports simultaneous measurement of 2 RS for L1 measurements different QCL Type-D on overlapping OFDM symbol(s), and
* Supports requirements for dual TCI state switch in TS38.133

Note: Above 3 bullets belong to one single UE capability | 16-2c | Yes | No | UE does not follow the requirements  | [Per band] | TDD only | FR2-1 only |  |  | Optional with capability signalling |
| 30. NR\_FR2\_multiRX\_DL | 30-2 | Fast beam sweeping for L1 measurement | Supports beam sweeping factor reduction for SSB-based layer 1 measurement. |   | No | N/A | UE’s L1 measurement delay is not reduced | Per band | TDD only | FR2-1 only |   | Candidate values: {2,4,6}  | Optional without capability signalling |

Table 3:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 30. NR\_FR2\_multiRX\_DL | 30-1 | Simultaneous reception of NR PDCCH/PDSCH and L1 measurement of RS or simultaneous L1 measurement of two RSes when the PDCCH/PDSCH and the L1 RS or two L1 RSes overlap in time and have different QCL Type-D | 1. Support of simultaneous reception of PDCCH/PDSCH and L1 measurement of RS overlapping in time and with different QCL Type-D.
2. Support of simultaneous L1 measurement of two RSes overlapping in time and with different QCL Type-D.
 | 16-2c, [2-29a: *groupBeamReporting*] | Yes | N/A | The UE does not support simultaneous reception/measurement | [Per FSPC] | N/A | FR2 only |  |  | Optional with capability signaling  |
| 30. NR\_FR2\_multiRX\_DL | 30-2 | Fast beam sweeping | Support of fast beam sweeping (or smaller beam sweeping factor N) for SSB-based or CSI-RS based L1 measurement.Candidate values for beam sweeping factor: {2,4,6} for FR2-1 | 16-2c, [2-29a: *groupBeamReporting*] | Yes | N/A | The UE does not support fast beam sweeping | [Per FSPC] | N/A | FR2 only |  |  | Optional with capability signaling |

* Recommended WF
	+ Based on outcome of issue 1-4-4 series, one table will be selected as baseline.

# Topic #2: RLM and BFD/CBD requirements

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318693 | Apple | **Proposal 1: Since RLM RSes may be transmitted from two TRPs in mDCI case, which is different from sDCI case, it is reasonable to add clarity to the specification. Option 2 is acceptable.****Proposal 2: It is necessary to have the condition “The two CSI-RS resources in the two sets q ̅\_0,0 and q ̅\_0,1 for beam failure detection [and both PDSCHs] are overlapped on the same OFDM symbol.” because the spatial filter used to measure CSI-RS could be different if the CSI-RS and PDCCH/PDSCH are not transmitted at the same time.****Proposal 3: To assume UE is activated with multi-Rx operation, the following conditions need to be met:****• The network configures groupBasedBeamReporting-r17 to the UE, and****• UE indicates to the network its preference of multi-RX operation, or****• The network has configured dual TCI states with different QCL Type D RS for simultaneous PDSCH reception within the past [X] seconds, during which UE has not indicated it prefers single-RX operation. Note X is FFS.** |
| R4-2319043 | vivo | **Proposal 1: For m-DCI scenario, reuse RLM requirements in section 8.1 of TS 38.133, without any clarification on multi-TRP operation.** **Proposal 2: PTRP=1 for CSI-RS based TRP specific BFD requirements for multi-Rx operation under following conditions,*** **Both CSI-RSs are not in any CSI-RS resource set with repetition ON**
* **The two CSI-RS resources in the two sets q ̅\_0,0 and q ̅\_0,1 for beam failure detection and both of the PDSCHs are on the same OFDM symbol(s), or either one of the CSI-RS resources in the two sets q ̅\_0,0 or q ̅\_0,1 and one of the PDSCHs with different QCL typeD are on the same OFDM symbol(s) when partially overlapping PDSCHs are scheduled.**
* **The CSI-RS in set q ̅\_0,0 has same QCL source as the active TCI state of one PDSCH, and the CSI-RS in set q ̅\_0,1 has same QCL source as the active TCI state of the other PDSCH.**
* **Resources of the active TCI states for the PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.**
 |
| R4-2319275 | Nokia, Nokia Shanghai Bell | [**Proposal 1: For multi-Rx capable UE, PTRP=1 under the following conditions:**](#_Toc149898120)* **Both CSI-RSs are not in any CSI-RS resource set with repetition ON**
* **The two CSI-RS resources in the two sets q0,0 and q0,1 for beam failure detection are overlapped on the same OFDM symbol.**
* **The two CSI-RS resources in the two sets q0,0 and q0,1 for beam failure detection have been reported as a resource group Rel-17 group-based RSRP report.**

[**Proposal 2: Capture in the RLM requirements that in m-DCI scenario, RLM RS during the evaluation period for out-of-sync and in-sync may originate from one or two TRPs.**](#_Toc149898121) |
| R4-2319276 | Nokia, Nokia Shanghai Bell | **Draft CR on multi-Rx TRP-specific BFD requirements** |
| R4-2319465 | OPPO | **Proposal 1: For m-DCI scenario, reuse RLM requirements in section 8.1 of TS 38.133, and no need to give any clarification or assumption on whether the RLM-RS originated from two TRPs or not.****Proposal 2: Remove the condition of ‘Both of the CSI-RSs and both of the PDCCH/PDSCHs are transmitted at the same time’.** |
| R4-2319466 | OPPO | **Draft CR for BFD and CBD related requirements of R18 multi-Rx DL** |
| R4-2320426 | ZTE Corporation | **Proposal 1: For mDCI scenario of intra-cell mTRP, no need to give any clarification or assumption on whether the RLM-RS originated from two TRPs or not.** |
| R4-2320433 | ZTE Corporation | **Draft CR on TRP specific link recovery for multi-Rx** |
| R4-2320463 | Ericsson | **Proposal 1**: Clarify that the RSs can be from the same or different TRPs (e.g., in Section 8.1.1 for RLM).**Observation 1**: For cell-specific CBD under multi-rx operation, measurement restrictions and scheduling availability enhancements are missing in the endorsed big CR.**Proposal 2**: Cell-specific CBD enhancements for measurement restrictions in FR2-1 are captured in section 8.5.6.3 (**missing in the Big CR from RAN4#108bis**).**Proposal 3**: Cell-specific CBD enhancements for scheduling availability in FR2-1 are captured in section 8.5.8.3 (**missing in the Big CR from RAN4#108bis**).**Observation 2**: For TRP-specific CBD under multi-rx operation, measurement restrictions and scheduling availability enhancements are missing in the endorsed big CR.**Proposal 4**: TRP-specific CBD enhancements for measurement restrictions in FR2-1 are captured in section 8.18.6.3 (**missing in the Big CR from RAN4#108bis**).**Proposal 5**: TRP-specific CBD enhancements for scheduling availability in FR2-1 are captured in section 8.18.9.3 (**missing in the Big CR from RAN4#108bis**). |
| R4-2320465 | Ericsson | **RLM requirements for UE with multi-rx chain in FR2** |

*The moderator can suggest a limited number of papers which could be presented.*

## Open issues summary

*Before f2f meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 2-1: Cell specific RLM and BFD/CBD

**Issue 2-1-5: Other aspects of RLM and cell specific BFD/CBD requirements for multi-Rx**

* Proposals
	+ Option 1a: (vivo)
		- For m-DCI scenario, reuse RLM requirements in section 8.1 of TS 38.133, without any clarification on multi-TRP operation.
	+ Option 1b: (OPPO, ZTE)
		- For mDCI scenario of intra-cell mTRP, no need to give any clarification or assumption on whether the RLM-RS originated from two TRPs or not.
	+ Option 2a: (Apple, Nokia)
		- Capture in the RLM requirements that in m-DCI scenario, RLM RS during the evaluation period for out-of-sync and in-sync may originate from one or two TRPs
	+ Option 2b: (Ericsson)
		- Clarify that the RSs can be from the same or different TRPs (e.g., in Section 8.1.1 for RLM)
* Recommended WF
	+ Further discuss.

### Sub-topic 2-2: TRP specific RLM and BFD/CBD

**Issue 2-2-1a: Overlapping condition for TRP specific BFD requirements enhancement for multi-Rx**

**In the last meeting, updated conditions for TRP specific BFD requirements enhancement for multi-Rx was agreed as following. The highlighted sub-bullets need further discussion.**

* Both CSI-RSs are not in any CSI-RS resource set with repetition ON
* The two CSI-RS resources in the two sets q ̅\_0,0 and q ̅\_0,1 for beam failure detection [and both PDSCHs] are overlapped on the same OFDM symbol.
* [The CSI-RS in set q ̅\_0,0 has same QCL source as the active TCI state of one PDSCH, and the CSI-RS in set q ̅\_0,1 has same QCL source as the active TCI state of the other PDSCH]
* Resources of the active TCI states for the two PDCCHs, or two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.
* [FFS how to capture UE is activated with multi-Rx operation]

**This issue focus on updating the 2nd and 3rd sub-bullets.**

* Proposals
	+ Option 1: (Apple)
		- The two CSI-RS resources in the two sets q ̅\_0,0 and q ̅\_0,1 for beam failure detection [and both PDSCHs] are overlapped on the same OFDM symbol.
	+ Option 2: (vivo)
		- The two CSI-RS resources in the two sets q ̅\_0,0 and q ̅\_0,1 for beam failure detection and both of the PDSCHs are on the same OFDM symbol(s), or either one of the CSI-RS resources in the two sets q ̅\_0,0 or q ̅\_0,1 and one of the PDSCHs with different QCL typeD are on the same OFDM symbol(s) when partially overlapping PDSCHs are scheduled.
		- The CSI-RS in set q ̅\_0,0 has same QCL source as the active TCI state of one PDSCH, and the CSI-RS in set q ̅\_0,1 has same QCL source as the active TCI state of the other PDSCH.
	+ Option 3: (Nokia, OPPO)
		- The two CSI-RS resources in the two sets q0,0 and q0,1 for beam failure detection are overlapped on the same OFDM symbol.
* Recommended WF
	+ Further discuss.

**Issue 2-2-1b: Multi-Rx activation condition for TRP specific BFD requirements enhancement for multi-Rx**

**In the last meeting, updated conditions for TRP specific BFD requirements enhancement for multi-Rx was agreed as following. The highlighted sub-bullets need further discussion.**

* Both CSI-RSs are not in any CSI-RS resource set with repetition ON
* The two CSI-RS resources in the two sets q ̅\_0,0 and q ̅\_0,1 for beam failure detection [and both PDSCHs] are overlapped on the same OFDM symbol.
* [The CSI-RS in set q ̅\_0,0 has same QCL source as the active TCI state of one PDSCH, and the CSI-RS in set q ̅\_0,1 has same QCL source as the active TCI state of the other PDSCH]
* Resources of the active TCI states for the two PDCCHs, or two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.
* [FFS how to capture UE is activated with multi-Rx operation]

**This issue focus on the 5th sub-bullet.**

* Proposals
	+ Option 1: (Apple)
		- The network configures groupBasedBeamReporting-r17 to the UE, and
		- UE indicates to the network its preference of multi-RX operation, or
		- The network has configured dual TCI states with different QCL Type D RS for simultaneous PDSCH reception within the past [X] seconds, during which UE has not indicated it prefers single-RX operation. Note X is FFS.
	+ Option 2: (vivo, Nokia)
		- No additional condition for indication of UE is activated with multi-Rx operation
* Recommended WF
	+ Further discuss.

# Topic #3: Scheduling/Measurement restrictions

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318500 | MediaTek inc. | **Proposal 1:** Remove **the following condition of measurement restriction relaxation for CSI-RS based L1 measurements.*** **[The two CSI-RS resources and both PDSCHs are overlapped on the same OFDM symbol].**
 |
| R4-2318653 | Apple | ***Proposal 1: Updated conditions/cases for scheduling restriction that can be relaxed for CSI-RS based L1 measurements for multi-Rx:**** ***The CSI-RS is not in a CSI-RS resource set with repetition ON.***
* ***The CSI-RS has same QCL source as the active TCI state of one of the PDSCHs and has different QCL-TypeD from the other PDSCH.***
* ***The CSI-RS and both of the PDSCHs are on the same OFDM symbol(s).***
* ***Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.***
* ***UE is activated with multi-Rx operation, i.e.,***
	+ ***The network configures groupBasedBeamReporting-r17 to the UE, and***
	+ ***UE indicates to the network its preference of multi-RX operation, or***
	+ ***The network has configured dual TCI states with different QCL Type D RS for simultaneous PDSCH reception within the past [X] seconds, during which UE has not indicated it prefers single-RX operation. Note X is FFS.***

***Proposal 2: Conditions that measurement restriction for CSI-RS based L1 measurements can be relaxed for multi-Rx:**** ***Both CSI-RSs are not in any CSI-RS resource set with repetition ON***
* ***The two CSI-RS resources and both PDSCHs are overlapped on the same OFDM symbol.***
* ***One CSI-RS has same QCL source as the active TCI state of one PDSCH, and the other CSI-RS has same QCL source as the active TCI state of the other PDSCH***
* ***Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.***
* ***UE is activated with multi-Rx operation, i.e.,***
	+ ***The network configures groupBasedBeamReporting-r17 to the UE, and***
	+ ***UE indicates to the network its preference of multi-RX operation, or***
	+ ***The network has configured dual TCI states with different QCL Type D RS for simultaneous PDSCH reception within the past [X] seconds, during which UE has not indicated it prefers single-RX operation. Note X is FFS.***
 |
| R4-2319044 | vivo | **Observation 1: UE can still be scheduled with partially overlapping PDSCHs if CSI-RS and only one of the PDSCHs with different QCL typeD are on the same OFDM symbol(s)****Proposal 1: Scheduling restriction relaxation can be made for CSI-RS based L1 measurements with multi-Rx when following conditions are met*** **The CSI-RS is not in a CSI-RS resource set with repetition ON.**
* **The CSI-RS and both of the PDSCHs are on the same OFDM symbol(s), or the CSI-RS and one of the PDSCHs with different QCL typeD are on the same OFDM symbol(s) when partially overlapping PDSCHs are scheduled.**
* **The CSI-RS has same QCL source as the active TCI state of one of the PDSCHs and has different QCL-TypeD from the other PDSCH.**
* **Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.**

**Proposal 2: Measurement restriction relaxation can be made for the CSI-RS based RLM/BFD/L1-RSRP measurements with multi-Rx when following conditions are met*** **Both CSI-RSs are not in any CSI-RS resource set with repetition ON**
* **The CSI-RSs and both of the PDSCHs are on the same OFDM symbol(s), or one of the CSI-RSs and one of the PDSCHs with different QCL typeD are on the same OFDM symbol(s) when partially overlapping PDSCHs are scheduled.**
* **One CSI-RS has same QCL source as the active TCI state of one PDSCH, and the other CSI-RS has same QCL source as the active TCI state of the other PDSCH**
* **Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.**
 |
| R4-2319277 | Nokia, Nokia Shanghai Bell | [Proposal 1: For a multi-Rx capable UE, there are no scheduling restrictions if the following conditions are met:](#_Toc149816167)* **The CSI-RS is not in a CSI-RS resource set with repetition ON.**
* **When the CSI-RS and both of the PDSCHs are on the same OFDM symbol(s):**
	+ **The CSI-RS has same QCL source as the active TCI state of one of the PDSCHs and has different QCL-TypeD from the other PDSCH.**
	+ **Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.**
* **When the CSI-RS and one PDSCH are on the same OFDM symbol(s):**
	+ **The CSI-RS has different QCL-TypeD from the PDSCH.**
	+ **The CSI-RS resource and the resource of the active TCI state of the PDSCH have been reported as a resource group in Rel-17 group-based RSRP report.**

[Proposal 2: For a multi-Rx capable UE, there are no measurement restrictions under the following conditions:](#_Toc149816168)* **Both CSI-RSs are not in any CSI-RS resource set with repetition ON**
* **The two CSI-RS resources are overlapped on the same OFDM symbol**
* **The two CSI-RS resources have been reported as a resource group in Rel-17 group-based RSRP report.**
 |
| R4-2319723 | Samsung | **Observation 1: The applicability of the measurement/scheduling restriction requirement is missing.****Proposal 1: RAN4 should define the applicability of the measurement/scheduling restriction requirement, i.e., sDCI or mDCI or both, otherwise UE can not know whether to/when to relax the measurement/scheduling restriction****Observation 2: For sDCI, the PDSCH scheduled by single PDCCH can be SDM, FDM, TDM, SFN, and Repetition, but the PDSCH is actually the one/single PDSCH****Proposal 2: For sDCI, it is not appropriate to indicate“two PDSCHs” and to define the condition of “both PDSCHs are overlapped on the same OFDM symbol”.****Proposal 3: The conditions of scheduling/measurement restriction relaxation for CSI-RS based L1 measurements is not applicable to sDCI.****Proposal 4: For mDCI, it is reasonable to indicate“two PDSCHs” and to define the condition of “both PDSCHs are overlapped on the same OFDM symbol”.****Proposal 5:****For FR2-1, when UE is capable of multiDCI-MultiTRP-r16 and configured with different CORESETPoolIndex, for the case PDSCHs are transmitted from two TRPs simultaneously, and two CSI-RSs are transmitted from different TRPs, measurement restriction relaxation can be made for CSI-RS based RLM/BFD/L1-RSRP with different Rx chains when following conditions are met****• Both CSI-RSs are not in any CSI-RS resource set with repetition ON****• The two CSI-RS resources and both PDSCHs are overlapped on the same OFDM symbol.****• One CSI-RS has same QCL source as the active TCI state of one PDSCH, and the other CSI-RS has same QCL source as the active TCI state of the other PDSCH****• Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.*** **[ UE is activated with multi-Rx operation]**

**Proposal 6:****For FR2-1, when UE is capable of multiDCI-MultiTRP-r16 and configured with different CORESETPoolIndex, for the case PDSCHs are transmitted from two TRPs simultaneously, and CSI-RS is transmitted from anyone of the TRPs, scheduling restriction relaxation can be made for CSI-RS based L1 measurement with different Rx chains when following conditions are met*** **The CSI-RS is not in a CSI-RS resource set with repetition ON.**
* **The CSI-RS has same QCL source as the active TCI state of one of the PDSCHs and has different QCL-TypeD from the other PDSCH.**
* **The CSI-RS and both of the PDSCHs are on the same OFDM symbol(s).**
* **Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.**
* **[ UE is activated with multi-Rx operation]**
 |
| R4-2320428 | ZTE Corporation | N/A |
| R4-2320760 | Ericsson | 1. scheduling restriction can be relaxed for CSI-RS based L1 measurements for multi-Rx under following conditions
* The CSI-RS is not in a CSI-RS resource set with repetition ON.
* The CSI-RS has same QCL source as the active TCI state of one of the PDSCHs and has different QCL-TypeD from the other PDSCH.
* For sDCI, The CSI-RS and both of the PDSCHs are on the same OFDM symbol(s).
* For mDCI, The CSI-RS and any one of the PDSCHs with different QCLed typeD are on the same OFDM symbol(s)
* Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report
1. measurement restriction for CSI-RS based L1 measurements can be relaxed for multi-Rx under following conditions
* Both CSI-RSs are not in any CSI-RS resource set with repetition ON
* For sDCI, the two CSI-RS resources and both PDSCHs are overlapped on the same OFDM symbol.
* For mDCI, two CSI-RS resources and any one of the PDSCH are overlapped on the same OFDM symbol.
* One CSI-RS has same QCL source as the active TCI state of one PDSCH, and the other CSI-RS has same QCL source as the active TCI state of the other PDSCH
* Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.
 |

*The moderator can suggest a limited number of papers which could be presented.*

## Open issues summary

*Before f2f meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 3-1: Scheduling restriction

*Sub-topic description:*

*Open issues and candidate options before f2f meeting:*

**Issue 3-1-1a: Overlapping condition for scheduling restriction**

**In the last meeting, updated conditions for scheduling restriction for multi-Rx was agreed as following. The highlighted sub-bullets need further discussion.**

* The CSI-RS is not in a CSI-RS resource set with repetition ON.
* The CSI-RS has same QCL source as the active TCI state of one of the PDSCHs and has different QCL-TypeD from the other PDSCH.
* The CSI-RS and both of the PDSCHs are on the same OFDM symbol(s).
	+ FFS: The CSI-RS and only one of the PDSCHs with different QCLed typeD are on the same OFDM symbol(s)
* Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.
* [FFS how to capture UE is activated with multi-Rx operation]

**This issue focus on updating the 3rd sub-bullet.**

* Proposals
	+ Option 1: (Apple, Samsung)
		- Only the condition that the CSI-RS and both of the PDSCHs are on the same OFDM symbol(s).
	+ Option 2: (vivo)
		- The CSI-RS and both of the PDSCHs are on the same OFDM symbol(s), or the CSI-RS and one of the PDSCHs with different QCL typeD are on the same OFDM symbol(s) when partially overlapping PDSCHs are scheduled.
	+ Option 3: (Nokia)
		- When the CSI-RS and both of the PDSCHs are on the same OFDM symbol(s):
			* The CSI-RS has same QCL source as the active TCI state of one of the PDSCHs and has different QCL-TypeD from the other PDSCH.
			* Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.
		- When the CSI-RS and one PDSCH are on the same OFDM symbol(s):
			* The CSI-RS has different QCL-TypeD from the PDSCH.
			* The CSI-RS resource and the resource of the active TCI state of the PDSCH have been reported as a resource group in Rel-17 group-based RSRP report.
	+ Option 4: (Ericsson)
		- For sDCI, The CSI-RS and both of the PDSCHs are on the same OFDM symbol(s).
		- For mDCI, The CSI-RS and any one of the PDSCHs with different QCLed typeD are on the same OFDM symbol(s)
* Recommended WF
	+ Further discuss.

**Issue 3-1-1b: Multi-Rx activation condition for scheduling restriction**

**In the last meeting, updated conditions for scheduling restriction for multi-Rx was agreed as following. The highlighted sub-bullets need further discussion.**

* The CSI-RS is not in a CSI-RS resource set with repetition ON.
* The CSI-RS has same QCL source as the active TCI state of one of the PDSCHs and has different QCL-TypeD from the other PDSCH.
* The CSI-RS and both of the PDSCHs are on the same OFDM symbol(s).
	+ FFS: The CSI-RS and only one of the PDSCHs with different QCLed typeD are on the same OFDM symbol(s)
* Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.
* [FFS how to capture UE is activated with multi-Rx operation]

**This issue focus on updating the 5th sub-bullet.**

* Proposals
	+ Option 1: (Apple)
		- The network configures groupBasedBeamReporting-r17 to the UE, and
		- UE indicates to the network its preference of multi-RX operation, or
		- The network has configured dual TCI states with different QCL Type D RS for simultaneous PDSCH reception within the past [X] seconds, during which UE has not indicated it prefers single-RX operation. Note X is FFS.
	+ Option 2: (vivo, Nokia, Ericsson)
		- No additional condition for indication of UE is activated with multi-Rx operation
* Recommended WF
	+ Further discuss.

### Sub-topic 3-2: Measurement restriction

*Sub-topic description:*

*Open issues and candidate options before f2f meeting:*

**Issue 3-2-2a: Overlapping condition for measurement restriction**

**In the last meeting, updated conditions for measurement restriction for multi-Rx was agreed as following. The highlighted sub-bullets need further discussion.**

* Both CSI-RSs are not in any CSI-RS resource set with repetition ON
* [The two CSI-RS resources and both PDSCHs are overlapped on the same OFDM symbol].
* One CSI-RS has same QCL source as the active TCI state of one PDSCH, and the other CSI-RS has same QCL source as the active TCI state of the other PDSCH
* Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.
* [FFS how to capture UE is activated with multi-Rx operation]

**This issue focus on updating the 2nd sub-bullet.**

* Proposals
	+ Option 1: (MTK)
		- Remove the condition that [The two CSI-RS resources and both PDSCHs are overlapped on the same OFDM symbol].
	+ Option 2: (Apple, Samsung)
		- Keep the condition that [The two CSI-RS resources and both PDSCHs are overlapped on the same OFDM symbol].
	+ Option 3: (vivo)
		- The CSI-RSs and both of the PDSCHs are on the same OFDM symbol(s), or one of the CSI-RSs and one of the PDSCHs with different QCL typeD are on the same OFDM symbol(s) when partially overlapping PDSCHs are scheduled.
	+ Option 4: (Nokia)
		- The two CSI-RS resources are overlapped on the same OFDM symbol.
		- In addition, remove 3rd sub-bullet.
	+ Option 5: (Ericsson)
		- For sDCI, the two CSI-RS resources and both PDSCHs are overlapped on the same OFDM symbol.
		- For mDCI, two CSI-RS resources and any one of the PDSCH are overlapped on the same OFDM symbol.
* Recommended WF
	+ Further discuss.

**Issue 3-2-2b: Multi-Rx activation condition for measurement restriction**

**In the last meeting, updated conditions for measurement restriction for multi-Rx was agreed as following. The highlighted sub-bullets need further discussion.**

* Both CSI-RSs are not in any CSI-RS resource set with repetition ON
* [The two CSI-RS resources and both PDSCHs are overlapped on the same OFDM symbol].
* One CSI-RS has same QCL source as the active TCI state of one PDSCH, and the other CSI-RS has same QCL source as the active TCI state of the other PDSCH
* Resources of the active TCI states for the two PDSCHs have been reported as a resource group in Rel-17 group-based RSRP report.
* [FFS how to capture UE is activated with multi-Rx operation]

**This issue focus on updating the 5th sub-bullet.**

* Proposals
	+ Option 1: (Apple)
		- The network configures groupBasedBeamReporting-r17 to the UE, and
		- UE indicates to the network its preference of multi-RX operation, or
		- The network has configured dual TCI states with different QCL Type D RS for simultaneous PDSCH reception within the past [X] seconds, during which UE has not indicated it prefers single-RX operation. Note X is FFS.
	+ Option 2: (vivo, Nokia, Ericsson)
		- No additional condition for indication of UE is activated with multi-Rx operation
* Recommended WF
	+ Follow conclusion of issue 3-1-1b.

# Topic #4: RRM performance requirements

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318698 | Apple | **Proposal 1: It is proposed to not verify UE support of 4-layer MIMO in RRM test cases.****Observation 1: From RF perspective, even a UE only supports one AoA offset, it is feasible to support dual TCI states to dual TCI states switching.****Proposal 2: To verify UE performance of dual TCI state switching, the final number of probes will be decided in the R18 FR2 OTA testing SI. RRM test cases can be designed following its conclusion.****Proposal 3: On the set of test cases, RAN4 can focus on the following ones: 1) Dual TCI state switching 2) L1 measurement period for GBBR 3) scheduling/measurement restriction, as UE’s multi-RX operation would be verified. Others are FFS.** |
| R4-2319047 | vivo | **Observation 1: 4 probes are needed in tests for dual TCI states switch.****Observation 2: At least 4 probes are needed in test for L1-RSRP with group-based beam reporting.*****Proposal 1: RRM tests which require 4 probes should be defined for at least TCI state switching.******Proposal 2: RAN4 to study whether 4 probes are enough for L1-RSRP with group-based beam reporting tests in which two beam pairs should be reported.******Proposal 3: Introduce test cases for FR2 multi-Rx as in Table 1.***Table 1 Test case list for multi-Rx

|  |  |  |  |
| --- | --- | --- | --- |
| **Test No.** | **Requirements** | **Tests**  | **AoA setup** |
| ***TC 1*** | Active TCI state switching delay for UE operating in FR2-1 and configured with groupBasedBeamReporting-r17 | MAC-CE based TCI state switch for s-DCI PDCCH reception | ***2 AoAs*** |
| ***TC 2*** | DCI based TCI state switch for s-DCI PDSCH reception | ***4 AoAs*** |
| ***TC 3*** | DCI based TCI state switch for m-DCI PDSCH reception | ***3 AoAs*** |
| ***TC 4*** | RRC based TCI state switch for PDCCH reception | ***4 AoAs*** |
| ***TC 5*** | Active TCI state list update for s-DCI | ***2 AoAs*** |
| ***TC 6*** | Fast beam sweeping related requirements | SSB-based RLM measurement delay | ***2 AoAs*** |
| ***TC 7*** | SSB-based BFD measurement delay | ***2 AoAs*** |
| ***TC 8*** | SSB-based TRP specific CBD measurement delay | ***2 AoAs*** |
| ***TC 9*** | L1-RSRP with GBBR measurement delay | ***2 AoAs or******4 AoAs*** |
| ***TC 10*** | Scheduling restriction related requirements. | Scheduling restriction for CSI-RS based RLM | ***2 AoAs*** |
| ***TC 11*** | Scheduling restriction for CSI-RS based BFD | ***2 AoAs*** |
| ***TC 12*** | Scheduling restriction for CSI-RS based L1-RSRP with GBBR | ***2 AoAs*** |
| ***TC 13*** | Scheduling restriction for CSI-RS based RLM | ***2 AoAs*** |
| ***TC 14*** | Measurement restriction related requirements. | Simultaneous measurement of CSI-RS based RLM and CSI-RS based L1-RSRP with GBBR |  |
| ***TC 15*** | Simultaneous measurement of CSI-RS based BFD and CSI-RS based L1-RSRP without GBBR |  |
| ***TC 10*** | TRP specific CSI-RS based BFD measurement delay |  |

***Proposal 4: The legacy accuracy requirements for L1-RSRP measurement apply for L1-RSRP measurements with group-based beam reporting.*** |
| R4-2319280 | Nokia, Nokia Shanghai Bell | [**Proposal 1: Reuse the existing L1-RSRP measurement accuracy requirements for group-based and non-group-based L1-RSRP measurements for a multi-Rx capable UE.**](#_Toc149923159)[**Proposal 2: 4-layer MIMO is not verified in RRM test cases.**](#_Toc149923160)[**Proposal 3: Define a test case to verify L1-RSRP accuracy requirements for group-based beam reporting.**](#_Toc149923161)[Observation 1: **For m-DCI, MAC-CE based dual TCI state switch for PDCCH involves overlapping TCI state switches from two TRPs with separate MAC-CEs.**](#_Toc149923162)[Observation 2: **For s-DCI, MAC-CE based dual TCI state switch for PDCCH is not considered.**](#_Toc149923163)[**Proposal 4: Define MAC-CE based dual TCI state switch test case for m-DCI mode to verify the time after which the UE shall be able to receive the two target TCI states indicated with two MAC-CEs simultaneously.**](#_Toc149923164)[Observation 3: **For RRC-based TCI state switch in m-DCI, it is sufficient that the UE passes the legacy test case, as the legacy requirements apply per TRP.**](#_Toc149923165)[Observation 4: **There is no existing test case for active TCI state list update or DCI-based TCI state switch. Such test cases are needed to be able to test dual TCI state switch for PDSCH for s-DCI and m-DCI.**](#_Toc149923166)[**Proposal 5: Define a combined test case for dual active TCI state list update and DCI-based TCI state switch for s-DCI and m-DCI.**](#_Toc149923167)[**Proposal 6: Define a test case for dual to dual TCI state switch using 4 probes.**](#_Toc149923168)[**Proposal 7: Define test case for single to dual and dual to single TCI state switch for the scenarios when the requirements differ from single-Rx requirements.**](#_Toc149923169)[**Proposal 8: Define a test case for group-based beam reporting using 4 probes, where the UE has to report two beam pairs from two different RS sets.**](#_Toc149923170)[**Proposal 9: For R18 multi-Rx reception, introduce one test case to verify the enhancement of faster beam sweeping on each type of SSB based L1 measurements.**](#_Toc149923171)[**Proposal 10: For TRP-specific BFD test case, also verify the PTRP factor reduction.**](#_Toc149923172)[**Proposal 11: For R18 multi-Rx reception, introduce one test case to verify the enhancement of scheduling restriction relaxation on CSI-RS based L1 measurements.**](#_Toc149923173)[**Proposal 12: RAN4 to define test cases for:**](#_Toc149923174)* N-factor (and PTRP factor) reduction and scheduling restrictions for:
	+ RLM
	+ Cell specific BFD and CBD
	+ TRP-specific BFD and CBD
	+ L1-RSRP measurements, GBBR-based and non-GBBR based
	+ [L1-SINR measurements, non-GBBR based]
* Dual TCI state switching:
	+ MAC-CE based switch: multi-DCI
	+ Active TCI state list and DCI-based TCI state switch (common test case): single-DCI and multi-DCI
* Accuracy requirements:
	+ GBBR-based L1-RSRP
 |
| R4-2319361 | Huawei, HiSilicon | **Proposal 1: 4-layer MIMO is not considered in RRM test cases.****Observation 1: Most RRM requirements are evaluated implicitly by demodulation performance (e.g. ACK/NACK feedback), which the SINR conditions shall be guaranteed.****Proposal 2: The AoAs for test cases shall be selected from the set that meet corresponding RF requirements. The selection of AoA offset shall wait for further RF conclusion.****Observation 2: RF testing for multi-RX is based on full degrees of freedom for AoA1 with fixed angular Offset(s) between AoA1 and AoA2.****Observation 3: Based on RF test methodology, for one test point, the result is “pass” or “not pass” for the selected AoA beam with fixed AoA offset.****Observation 4: Based on current RF test methodology, for one test point, one qualified AoA pair with fixed offset can be found. However, for case 6, it requires two qualified AoA pairs for one test point, which cannot be supported.****Observation 5: The purpose of have dual TCI state switching test case is to verify that UE can have two panel/Rx ready for simultaneous data reception as required by the TCI switching delay.****Observation 6: Case#2 ([RS1] to [RS2, RS3]) and case#6 [RS1, RS2] to [RS3, RS4] can serve the same purpose that UE shall be ready for simultaneous data reception with different QCL typed with two new TCI states.****Proposal 3: RAN4 don't define test cases for dual TCI state from dual TCI to dual TCI ( [RS1, RS2] to [RS3, RS4]) where 4 active probes are needed, since the performance can be verified by Single TCI to dual TCI( [RS1] to [RS2, RS3]).****Proposal 4: For R18 multi-Rx reception, it is suggested to introduce one test case to verify the enhancement of faster beam sweeping on each type of SSB based L1 measurements.****Proposal 5: For R18 multi-Rx reception, it is suggested to introduce one test case to verify the enhancement of scheduling restriction relaxation on CSI-RS based L1 measurements.** |
| R4-2319468 | OPPO | **Proposal 1: Suggest to introduce one test case to verify the enhancement of faster beam sweeping for SSB based RLM measurements for R18 multi-Rx reception:** * **TC1: SSB based RLM Out-of-sync Test with faster beam sweeping for FR2 PCell in non-DRX mode**

**Proposal 2: Suggest to introduce one test case to verify the enhancement of faster beam sweeping for SSB based BFD measurements*** **TC2: SSB based BFD and LR Test with faster beam sweeping for FR2 PCell in non-DRX mode**

**Proposal 3: Suggest to introduce one test case to verify the enhancement of faster beam sweeping for SSB based L1-RSRP measurements*** **TC3: SSB based L1-RSRP measurement with faster beam sweeping when DRX is not used**

**Proposal 4: RAN4 to discuss whether to introduce test case to verify scheduling/measurement restriction relaxation on CSI-RS based L1 measurement for R18 multi-Rx reception****Proposal 5: RAN4 not to test the case of dual TCI state switching from dual TCI to dual TCI.** |
| R4-2320464 | Ericsson | **Proposal 1 (Accuracy requirements)**: The legacy accuracy requirements in section 10.1.20 of TS 38.133 apply for L1-RSRP measurements under multi-rx operation, with a clarification that multi-rx chain L1-RSRP accuracy requirements apply for FR2-1.**Proposal 2 (Accuracy requirements)**: No new accuracy requirements section is created for L1-RSRP measurements under multi-rx operation.**Proposal 3 (RRM test cases general)**: RAN4 will discuss and strive to agree on a list of RRM test cases for multi-rx chain UE in RAN4#109.**Proposal 4 (RRM test cases general)**: At high-level, the list of test cases shall include test cases for all of:Dual active TCI state switching,RLM,Link recovery,L1-RSRP measurement period.**Proposal 5 (L1-RSRP test cases)**: For L1-RSRP, measurement delay and measurement accuracy tests are specified for GBBR.**Proposal 6 (Active TCI state test cases)**: For dual active TCI state switching, RAN4 will specify test cases at least for the switching from single to dual TCI state.**Proposal 7 (Active TCI state test cases)**: Deprioritize test cases for dual-to-dual active TCI state switching.**Proposal 8 (Active TCI state test cases)**: For dual active TCI state switching delay, at least the following test cases are specified:DCI-based based dual active TCI state switching with sDCI,DCI-based based dual active TCI state switching with mDCI,MAC-CE based dual active TCI state switching with sDCI,MAC-CE based dual active TCI state switching with mDCI,FFS: RRC-based dual active TCI state switching.**Proposal 9 (Active TCI state test cases)**: For active TCI state list update, RAN4 prioritizes test cases with sDCI.**Proposal 10 (measurement restrictions test cases)**: Measurement restrictions test cases are specified for:RLM,L1-RSRP,BFD (cell-specific, TRP-specific),CBD (cell-specific, TRP-specific).**Proposal 11 (scheduling availability test cases)**: Scheduling availability test cases are specified for:RLM,L1-RSRP,BFD (cell-specific, TRP-specific),CBD (cell-specific, TRP-specific).**Proposal 12 (faster beam sweeping test cases)**: RAN4 defines test cases for faster beam sweeping. |
| R4-2320513 | ZTE Corporation | **Proposal 1: 4-layer MIMO is not considered in RRM test cases, it can be tested in demod test.****Proposal 2: Introduce test cases to verify the fast beam sweeping, the candidate test case including the SSB based GBBR L1-RSRP measurement, non-GBBR L1-RSRP measurement, RLM, BFD and CBD.****Proposal 3: Introduce test cases to verify the scheduling/measurement restriction relaxation when CSI-RS involved in the L1 measurements.****Proposal 4: The legacy accuracy requirements in section 10.1.20 of TS 38.133 apply for L1-RSRP measurements under multi-rx operation, with a clarification that multi-rx chain L1-RSRP accuracy requirements apply for FR2-1.** |

*The moderator can suggest a limited number of papers which could be presented.*

## Open issues summary

*Before f2f meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 4-1: Test cases design

*Sub-topic description:*

*Open issues and candidate options before f2f meeting:*

**Issue 4-1: Whether to consider 4-layer MIMO in RRM test cases**

* Proposals
	+ Option 1: (Apple, Huawei)
		- 4-layer MIMO is not verified in RRM test cases
* Recommended WF
	+ Agree on option 1.

**Issue 4-2: AoA selection in RRM test cases**

* Proposals
	+ Option 1: (Huawei)
		- The AoAs for test cases shall be selected from the set that meet corresponding RF requirements. The selection of AoA offset shall wait for further RF conclusion.
* Recommended WF
	+ Further discuss.

**Issue 4-3: Number of probes in RRM test cases**

* Proposals
	+ Option 1: (Apple)
		- To verify UE performance of dual TCI state switching, the final number of probes will be decided in the R18 FR2 OTA testing SI. RRM test cases can be designed following its conclusion.
	+ Option 2: (vivo)
		- RRM tests which require 4 probes should be defined for at least TCI state switching.
		- RAN4 to study whether 4 probes are enough for L1-RSRP with group-based beam reporting tests in which two beam pairs should be reported.
	+ Option 3: (Nokia)
		- Define a test case for dual to dual TCI state switch using 4 probes.
	+ Option 4: (Huawei)
		- RAN4 don't define test cases for dual TCI state from dual TCI to dual TCI ( [RS1, RS2] to [RS3, RS4]) where 4 active probes are needed, since the performance can be verified by Single TCI to dual TCI( [RS1] to [RS2, RS3]).
* Recommended WF
	+ Further discuss.

**Issue 4-4: Test case(s) for fast beam sweeping**

* Proposals
	+ Option 1: (Nokia, Huawei, Ericsson)
		- Introduce one test case to verify the enhancement of faster beam sweeping on each type of SSB based L1 measurements
	+ Option 2: (vivo)
		- SSB-based RLM measurement delay
		- SSB-based BFD measurement delay
		- SSB-based TRP specific CBD measurement delay
		- L1-RSRP with GBBR measurement delay
	+ Option 3: (OPPO)
		- TC1: SSB based RLM Out-of-sync Test with faster beam sweeping for FR2 PCell in non-DRX mode
		- TC2: SSB based BFD and LR Test with faster beam sweeping for FR2 PCell in non-DRX mode
		- TC3: SSB based L1-RSRP measurement with faster beam sweeping when DRX is not used
	+ Option 4: (ZTE)
		- Introduce test cases to verify the fast beam sweeping, the candidate test case including the SSB based GBBR L1-RSRP measurement, non-GBBR L1-RSRP measurement, RLM, BFD and CBD.
* Recommended WF
	+ Further discuss.

**Issue 4-5: Test case(s) for scheduling restriction**

* Proposals
	+ Option 1: (Nokia, Huawei, ZTE)
		- Introduce one test case to verify the enhancement of scheduling restriction relaxation on CSI-RS based L1 measurements.
	+ Option 2: (vivo)
		- Scheduling restriction for CSI-RS based RLM
		- Scheduling restriction for CSI-RS based BFD
		- Scheduling restriction for CSI-RS based L1-RSRP with GBBR
		- Scheduling restriction for CSI-RS based RLM
	+ Option 3: (OPPO)
		- RAN4 to discuss whether to introduce test case to verify scheduling restriction relaxation on CSI-RS based L1 measurement for R18 multi-Rx reception
	+ Option 4: (Ericsson)
		- RLM
		- L1-RSRP
		- BFD (cell-specific, TRP-specific)
		- CBD (cell-specific, TRP-specific)
* Recommended WF
	+ Further discuss.

**Issue 4-6: Test case(s) for measurement restriction**

* Proposals
	+ Option 1: (vivo)
		- Simultaneous measurement of CSI-RS based RLM and CSI-RS based L1-RSRP with GBBR
		- Simultaneous measurement of CSI-RS based BFD and CSI-RS based L1-RSRP without GBBR
		- TRP specific CSI-RS based BFD measurement delay
	+ Option 2: (Nokia)
		- For TRP-specific BFD test case, also verify the PTRP factor reduction.
	+ Option 3: (Huawei, ZTE)
		- Introduce one test case to verify the enhancement of measurement restriction relaxation on CSI-RS based L1 measurements.
	+ Option 4: (OPPO)
		- RAN4 to discuss whether to introduce test case to verify measurement restriction relaxation on CSI-RS based L1 measurement for R18 multi-Rx reception
	+ Option 5: (Ericsson)
		- RLM
		- L1-RSRP
		- BFD (cell-specific, TRP-specific)
		- CBD (cell-specific, TRP-specific)
* Recommended WF
	+ Further discuss.

**Issue 4-7: Test case(s) for TCI state switching**

* Proposals
	+ Option 1: (vivo)
		- MAC-CE based TCI state switch for s-DCI PDCCH reception (2 AoAs)
		- DCI based TCI state switch for s-DCI PDSCH reception (4 AoAs)
		- DCI based TCI state switch for m-DCI PDSCH reception (3 AoAs)
		- RRC based TCI state switch for PDCCH reception (4 AoAs)
		- Active TCI state list update for s-DCI (2 AoAs)
	+ Option 2: (Nokia)
		- Define MAC-CE based dual TCI state switch test case for m-DCI mode to verify the time after which the UE shall be able to receive the two target TCI states indicated with two MAC-CEs simultaneously.
		- For RRC-based TCI state switch in m-DCI, it is sufficient that the UE passes the legacy test case, as the legacy requirements apply per TRP.
		- There is no existing test case for active TCI state list update or DCI-based TCI state switch. Such test cases are needed to be able to test dual TCI state switch for PDSCH for s-DCI and m-DCI.
		- Define a combined test case for dual active TCI state list update and DCI-based TCI state switch for s-DCI and m-DCI.
		- Define a test case for dual to dual TCI state switch using 4 probes.
		- Define test case for single to dual and dual to single TCI state switch for the scenarios when the requirements differ from single-Rx requirements.
	+ Option 3: (OPPO)
		- RAN4 not to test the case of dual TCI state switching from dual TCI to dual TCI.
	+ Option 4: (Ericsson)
		- DCI-based based dual active TCI state switching with sDCI
		- DCI-based based dual active TCI state switching with mDCI
		- MAC-CE based dual active TCI state switching with sDCI
		- MAC-CE based dual active TCI state switching with mDCI
		- FFS: RRC-based dual active TCI state switching.
		- Active TCI state list update, RAN4 prioritizes test cases with sDCI.
* Recommended WF
	+ Further discuss.

**Issue 4-8: Test case(s) for group-based beam reporting**

* Proposals
	+ Option 1: (Nokia)
		- Define a test case for group-based beam reporting using 4 probes, where the UE has to report two beam pairs from two different RS sets.
	+ Option 2: (vivo, Apple)
		- L1-RSRP with GBBR measurement delay with 2 AoAs or 4AoAs.
	+ Option 3: (Ericsson)
		- For L1-RSRP, measurement delay and measurement accuracy tests are specified for GBBR
* Recommended WF
	+ Agree on introducing test case to verify L1-RSRP group-based beam reporting.
		- FFS number of AoAs/Probes

**Issue 4-9: List of test case(s) for multi-Rx in Rel-18**

* Proposals
	+ Option 1: (vivo)
		- Introduce test cases for FR2 multi-Rx as in Table 1

Table 1 Test case list for multi-Rx

|  |  |  |  |
| --- | --- | --- | --- |
| **Test No.** | **Requirements** | **Tests**  | **AoA setup** |
| ***TC 1*** | Active TCI state switching delay for UE operating in FR2-1 and configured with groupBasedBeamReporting-r17 | MAC-CE based TCI state switch for s-DCI PDCCH reception | ***2 AoAs*** |
| ***TC 2*** | DCI based TCI state switch for s-DCI PDSCH reception | ***4 AoAs*** |
| ***TC 3*** | DCI based TCI state switch for m-DCI PDSCH reception | ***3 AoAs*** |
| ***TC 4*** | RRC based TCI state switch for PDCCH reception | ***4 AoAs*** |
| ***TC 5*** | Active TCI state list update for s-DCI | ***2 AoAs*** |
| ***TC 6*** | Fast beam sweeping related requirements | SSB-based RLM measurement delay | ***2 AoAs*** |
| ***TC 7*** | SSB-based BFD measurement delay | ***2 AoAs*** |
| ***TC 8*** | SSB-based TRP specific CBD measurement delay | ***2 AoAs*** |
| ***TC 9*** | L1-RSRP with GBBR measurement delay | ***2 AoAs or******4 AoAs*** |
| ***TC 10*** | Scheduling restriction related requirements. | Scheduling restriction for CSI-RS based RLM | ***2 AoAs*** |
| ***TC 11*** | Scheduling restriction for CSI-RS based BFD | ***2 AoAs*** |
| ***TC 12*** | Scheduling restriction for CSI-RS based L1-RSRP with GBBR | ***2 AoAs*** |
| ***TC 13*** | Scheduling restriction for CSI-RS based RLM | ***2 AoAs*** |
| ***TC 14*** | Measurement restriction related requirements. | Simultaneous measurement of CSI-RS based RLM and CSI-RS based L1-RSRP with GBBR |  |
| ***TC 15*** | Simultaneous measurement of CSI-RS based BFD and CSI-RS based L1-RSRP without GBBR |  |
| ***TC 16*** | TRP specific CSI-RS based BFD measurement delay |  |

* + Option 2: (Apple)
		- Dual TCI state switching
		- L1 measurement period for GBBR
		- scheduling/measurement restriction, as UE’s multi-RX operation would be verified. Others are FFS.
	+ Option 3: (Nokia)
		- N-factor (and PTRP factor) reduction and scheduling restrictions for:
			* RLM
			* Cell specific BFD and CBD
			* TRP-specific BFD and CBD
			* L1-RSRP measurements, GBBR-based and non-GBBR based
			* [L1-SINR measurements, non-GBBR based]
		- Dual TCI state switching:
			* MAC-CE based switch: multi-DCI
			* Active TCI state list and DCI-based TCI state switch (common test case): single-DCI and multi-DCI
		- Accuracy requirements:
			* GBBR-based L1-RSRP
	+ Option 4: (Ericsson)
		- Dual active TCI state switching
		- RLM
		- Link recovery
		- L1-RSRP measurement period
* Recommended WF
	+ Further discuss.

### Sub-topic 4-2: Accuracy requirements

*Sub-topic description:*

*Open issues and candidate options before f2f meeting:*

**Issue 4-7: Accuracy requirements for multi-Rx in Rel-18**

* Proposals
	+ Option 1: (vivo, Nokia)
		- The legacy accuracy requirements for L1-RSRP measurement apply for L1-RSRP measurements with group-based beam reporting.
	+ Option 2: (ZTE)
		- The legacy accuracy requirements in section 10.1.20 of TS 38.133 apply for L1-RSRP measurements under multi-rx operation, with a clarification that multi-rx chain L1-RSRP accuracy requirements apply for FR2-1.
	+ Option 3: (Ericsson)
		- The legacy accuracy requirements in section 10.1.20 of TS 38.133 apply for L1-RSRP measurements under multi-rx operation, with a clarification that multi-rx chain L1-RSRP accuracy requirements apply for FR2-1.
		- No new accuracy requirements section is created for L1-RSRP measurements under multi-rx operation.
* Recommended WF
	+ Further discuss.

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