**3GPP TSG RAN WG4 Meeting #111 R4-241xx**

**Fukuoka City, Fukuoka, Japan, 20th – 24th May, 2024**

**Agenda item:** 7.3.4

**Source:** Moderator (vivo)

**Title:**  Ad-hoc minutes for NR FR2 multi-Rx WI

**Document for:** Approval

# Introduction

In this meeting, there are two email threads dedicated for FR2 multi-Rx chain DL reception, i.e., [111][203] FR2\_multiRx\_part1 and [111][204] FR2\_multiRx\_part2. Topic summaries for the two email threads [1, 2] summarized open issues in this meeting for the WI.

Since performance part should be completed in this meeting, the ad-hoc session is mainly to handle some issues for performance part. If time allows, core part maintenance can also be handled. The following issues are to be handled firstly.

For Topic #2:

Issue 2-2a: Whether and how to define new 2AoA setup for multi-Rx

Issue 2-7: Test case(s) for dual TCI state switching for m-DCI

Issue 2-7a: Test case(s) for dual TCI state switching for s-DCI

Issue 2-12 – Issue 2-16

For Topic #3:

Issue 1-1-1: When is UE considered to be in multi-rx operation

Issue 1-1-2: End point for fast beam sweeping application.

# Topic #2: Core requirements test cases

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

### Sub-topic 2-1: Test cases design

**Issue 2-2a: Whether and how to define new 2AoA setup for multi-Rx**

* Proposals
	+ Option 1: (Apple)
		- 2AoA setup for multi-RX should focus on those AoA pairs with a UE-declared AoA separation that can meet the throughput requirement.
		- RX beam peak direction defined for R15 single AoA reception does not need to be singled out for 2AoA setup.
	+ Option 2: (vivo)
		- Define one new 2 AoAs setup for multi-Rx with AoA beams from non-Rx beam peak direction.
		- It can be based on legacy AoA setup 3 with new AoA selection principle and angular offset.
	+ Option 3: (Nokia)
		- Introduce new 3 AoA setup for simultaneous reception in dual-to-dual TCI switching test cases.
		- Introduce new 2 AoA setup for simultaneous reception.
	+ Option 4: (Huawei)
		- New AoA Setup X1: 2 AoAs
			* There are 2 active probes in the test. The DL signals, and noise if applicable, transmitted from the two active probes, align to directions (AoAs) which are from the set of directions corresponding to the EIS spherical coverage percentile of the DUT as defined in clause 7.3K.3 of TS 38.101-2 [19]. And the DL signals, and noise if applicable, transmitted from one of the two active probes is also align to directions (AoAs) which are from the set of directions corresponding to the EIS spherical coverage percentile of the DUT as defined in clause 7.3.4 of TS 38.101-2 [19]. The relative angular offset between the directions (AoAs) of the 2 active probes is based on the UE’s declared orientation as defined in clause 7.3K.3 of TS 38.101-2 [19].
		- New AoA Setup X2: 3 AoAs
			* There are 3 active probes in the test. The DL signals, and noise if applicable, transmitted from the two of active probes, align to directions (AoAs) which are from the set of directions corresponding to the EIS spherical coverage percentile of the DUT as defined in clause 7.3K.3 of TS 38.101-2 [19]. And the DL signals, and noise if applicable, transmitted from the third probe is also align to directions (AoAs) which are from the set of directions corresponding to the EIS spherical coverage percentile of the DUT as defined in clause 7.3.4 of TS 38.101-2 [19]. The relative angular offset between the directions (AoAs) of the first and second active probes is based on the UE’s declared orientation as defined in clause 7.3K.3 of TS 38.101-2 [19].
	+ Option 5: (Samsung)
		- RAN4 to define the following new 2AoA setups for multi-Rx
			* 2 AoAs, both AoAs are in non Rx beam peak directions
				+ RRM need to consider the declared AoA separation and all the corresponding directions defined in RF requirements
			* 2 AoAs, 1 AoA in Rx beam peak direction, 1 in non Rx beam peak without change in direction
			* 2 AoAs, 1 AoA in Rx beam peak direction, 1 in non Rx beam peak with change in direction
				+ RRM can consider the RF declared AoA separation and all directions as the priority potential selection
		- RAN4 to define a new 3AoA setup for multi-Rx to test dual TCI switching case
	+ Option 6: (Ericsson)
		- RAN4 to define new AoA set up with following AoA in the test set up
			* One AoA in the Rx beam peak direction and other AoA in Spherical coverage direction
			* Both the AoA in Spherical coverage direction or non-beam peak direction.
		- SetupX1a:
			* There are 3 active probes in the test and at any time UE needs to receive at most on two probes simultaneously. The DL signals, and noise are transmitted from the three active probes. The AoA separation between the two active probes on which UE needs to receive simultaneously is 30, 60, 90, 120 and 150 degrees. The active probes are in spherical coverage direction.
		- SetupX1B:
			* There are 2 active probes in the test. The DL signals, and noise are transmitted from the two active probes. UE need to receive on the active probes simultaneously. The AoA separation between the two active probes is 30, 60, 90, 120 and 150 degrees. The active probes are in spherical coverage direction.
		- Setup 1C:
			* There are 2 active probes in the test. The DL signals, and noise are transmitted from the two active probes. The AoA separation between the two active probes is 30, 60, 90, 120 and 150 degrees. The active probes are in spherical coverage direction.
* Recommended WF
	+ Discuss and agree on the following
		- Introduce new AoA Setup X1: 3 AoAs, 1 AoA in Rx beam peak direction, 2 AoAs in non Rx beam peak directions
			* The single AoA is aligned to the UE Rx beam peak direction as defined in TS 38.101-2.
			* The AoA pair for simultaneous reception with different QCL-typeD is from [the set of qualified AoA pairs according to the spherical coverage requirement for simultaneous reception from multiple directions as defined in clause 7.3K.3 of TS 38.101-2].
			* The relative angular offset between the directions of the AoA pair is based on the UE’s declared orientation as defined in clause 7.3K.3 of TS 38.101-2.
		- Introduce new AoA Setup X2: 2 AoAs, both AoAs are in non Rx beam peak directions
			* The 2 AoAs for simultaneous reception with different QCL-typeD is from [the set of qualified AoA pairs according to the spherical coverage requirement for simultaneous reception from multiple directions as defined in clause 7.3K.3 of TS 38.101-2].
			* The relative angular offset between the directions of the 2 AoAs is based on the UE’s declared orientation as defined in clause 7.3K.3 of TS 38.101-2.
		- FFS introduce new AoA Setup X3: 2 AoAs, 1 AoA in Rx beam peak direction, 1 AoA in non Rx beam peak without change in direction
		- FFS introduce new AoA Setup X4: 1 AoA in Rx beam peak direction, 1 AoA in non Rx beam peak with change in direction

**Discussion.**

RS: We may consider it in test setups.

QC: It may not always be possible if 1 AoA can always be in Rx beam peak direction.

RS: Based on test experience, any particular reason that 1 AoA has to be in the Rx beam peak direction. It is prefer to keep it as in spherical coverage direction.

OPPO: What about from [RS1, RS2] to [RS1, RS3]?

**Tentative Agreements:**

* Introduce new AoA Setup X1: 3 AoAs
	+ 1 AoA is from the set of directions corresponding to the EIS spherical coverage percentile of the DUT as defined in clause 7.3.4 of TS 38.101-2 [19] for each UE power class.
	+ The AoA pair for simultaneous reception with different QCL-typeD is from the set of [qualified AoA pairs] according to the spherical coverage requirement for simultaneous reception from multiple directions as defined in clause 7.3K.3 of TS 38.101-2.
	+ The relative angular offset between the directions of the AoA pair is based on the UE’s declared [AoA7 separation and UE] orientation as defined in clause 7.3K.3 of TS 38.101-2.

**Discussion:**

**Ericson: Which test case is to use this setup?**

**Agreements:**

* Introduce new AoA Setup X2: 2 AoAs, both AoAs are in non Rx beam peak directions
	+ The 2 AoAs for simultaneous reception with different QCL-typeD is from the set of [qualified AoA pairs] according to the spherical coverage requirement for simultaneous reception from multiple directions as defined in clause 7.3K.3 of TS 38.101-2.
	+ The relative angular offset between the directions of the 2 AoAs is based on the UE’s declared orientation as defined in clause 7.3K.3 of TS 38.101-2.

**Issue 2-7: Test case(s) for dual TCI state switching for m-DCI**

* Proposals
	+ Option 1: (ZTE)
		- It is suggested to verify the dual to dual active TCI state switching from [RS 1, RS 2] to [RS 1, RS3] under the assumption of 3 active probes.
	+ Option 2: (vivo)
		- Define test cases for verifying m-DCI based dual TCI states switch requirements with 3 probes, i.e., from [RS1] to [RS2, RS3].
		- Not to define test cases MAC-CE based dual TCI states switch with m-DCI.
	+ Option 3: (Nokia)
		- Test cases for DCI based and MAC-CE dual TCI state switch for m-DCI need to be defined.
* Recommended WF
	+ Discuss and agree on the following.
		- Introduce one test case for DCI based dual TCI state switch for m-DCI. Discuss following setup
			* Option 1: from [RS1] to [RS2, RS3]
			* Option 2: from [RS 1, RS 2] to [RS 1, RS3]
			* Option 3: from [RS1, RS2] to [RS3, RS4] with 3 active probes.
		- Discuss test case for MAC-CE based dual TCI state switch for m-DCI

Tentative Agreement (the tentative agreement can be confirmed if it is feasible for testing):

* From [RS1, RS2] (Probe 1 and 2, no simultaneous transmission) to [RS3, RS4] (Probe 1 and 3) with 3 active probes.
	+ 4 TCI states, two of them share the same probe.
	+ Probe 1 with RS1 and RS3, [fulfilling legacy EIS requirement]
	+ Probe 2 with RS2, [fulfilling legacy EIS requirement]
	+ Probe 3 with RS4
	+ [Probe 1 and Probe 3 (after TCI state switching) fulfill the 2AoA setup requirement]

**Discussion:**

**Apple: Can we always ensure probe 1 is from legacy EIS spherical coverage point and at the same time fulfil multi-Rx EIS spherical coverage?**

**R$S: RAN5 will make sure all the side conditions will be met for the test. If there is something wrong, RAN5 can come back with the issue.**

**Agreement:**

Introduce one test case for DCI-based dual TCI state switching for m-DCI

* From [RS1, RS2] (Probe 1 and 2, no simultaneous transmission) to [RS3, RS4] (Probe 1 and 3) with 3 active probes.
	+ Side conditions
		- Probe 1 & 3 shall fulfill the mRx spherical coverage EIS requirement (angular offset as declared by the UE). Note: Aligned with 2AoA selected as we agreed.
		- In addition, Probe 1 & 2 shall fulfill individually the legacy spherical coverage EIS requirement and angular offset from the legacy 2AoA table, i.e. selection is equivalent to a single pair from Setup 3
	+ Signal mapping
		- RS1 & RS3 are mapped to Probe 1
		- RS2 is mapped to Probe 2
		- RS4 is mapped to Probe 3

**Discussion:**

**Apple: Any additional value to have the test?**

**Nokia: It is fine to skip the test.**

**Agreement:**

* Not to define test case for MAC-CE based dual TCI state switch for m-DCI.

**Issue 2-7a: Test case(s) for dual TCI state switching for s-DCI**

Agreements in the last meeting:

* TC1: DCI based TCI state switch for s-DCI
	+ As starting point: [RS1] to [RS1, RS2].
	+ FFS [RS1, RS2] to [RS1, RS3].
	+ FFS [RS1, RS2] to [RS1]
	+ Active TCI state list update is included during the test
* TC2: MAC-CE based dual TCI state switch for s-DCI for PDCCH repetition
	+ [RS1] to [RS2, RS3]
* Proposals
	+ Option 1: (Xiaomi)
		- Don’t define testcase for MAC-CE based dual TCI state switch for s-DCI for PDCCH repetition.
	+ Option 2: (ZTE)
		- It is suggested to verify the dual to single active TCI state switching from [RS 1, RS 2] to RS 1 to verify no switching delay and no interruption.
	+ Option 3: (vivo)
		- In test case for s-DCI based dual TCI states switch, it is defined with from [RS1] to [RS2, RS3].
	+ Option 4: (Huawei)
		- Verify the requirements (no switching delay) for [RS1, RS2] to [RS1] at the same TC for [RS1] to [RS1, RS2].
		- In details, TE sends the commands to DUT to change the TCI states from [RS1, RS2] to [RS1] after the TCI state switching from [RS1] to [RS1, RS2].
	+ Option 5: (Ericsson)
		- RS1 to (RS1, RS2) switch for DCI based TCI state switch for s-DCI
		- RS1 to (RS2, RS3) switch for MAC-CE based dual TCI state switch for s-DCI for PDCCH repetition
* Recommended WF
	+ Discuss whether this is any issue on defining test case for MAC-CE based dual TCI state switch for s-DCI for PDCCH repetition.
	+ Discuss whether to define test case for DCI based dual TCI state switch for s-DCI with dual to single active TCI state switching from [RS 1, RS 2] to RS 1.
		- It may be combined in the same test case for [RS1] to [RS1, RS2].
	+ Discuss whether to change setup from [RS1] to [RS1, RS2] to [RS1] to [RS2, RS3] for DCI based dual TCI state switch for s-DCI.

Discuss whether this is any issue on defining test case for MAC-CE based dual TCI state switch for s-DCI for PDCCH repetition.

**Discussion:**

**Nokia: There is not much difference from one TCI state switch.**

**Xiaomi: The delay requirements are similar to legacy one. We are open to discuss.**

**Moderator: No new conclusion is needed.**

Discuss whether to define test case for DCI based dual TCI state switch for s-DCI with dual to single active TCI state switching from [RS 1, RS 2] to RS 1.

* It may be combined in the same test case for [RS1] to [RS1, RS2].

Discussion：

Huawei: We prefer to have the test as there are requirements being specified, and it can be included in one test case with original one.

QC: UE always switch beam back and forth for receiving PDCCH and PDSCH.

Tentative Agreement: (only to be checked from testability perspective)

* + Define test case for DCI based dual TCI state switch for s-DCI with dual to single active TCI state switching from [RS 1, RS 2] to RS 1.
		- It is combined in the same test case for [RS1] to [RS1, RS2].

Discuss whether to change setup from [RS1] to [RS1, RS2] to [RS1] to [RS2, RS3] for DCI based dual TCI state switch for s-DCI.

Does RS1 has to be from the Rx beam peak direction?

Discussion:

Ericson: RS1 doesn’t need to be from Rx beam peak direction.

R&S: If one probe is from Rx beam peak direction, there is restriction on finding out suitable beam pair with this peak direction. All the probes are one the same plane. The more probes active in the test, the more difficult to set the SNR when DL signals are transmitted on the same OFDM.

### Sub-topic 2-2: Test setup

*Sub-topic description:*

*Open issues and candidate options before f2f meeting:*

**Issue 2-12: Test setup for fast beam sweeping**

* Proposals
	+ Option 1: (Samsung)
		- No DRX is configured for test setup for fast beam sweeping
		- The new 2AoA setup: 2AoAs, both AoAs are in spherical coverage directions shall be applied for RLM OOS non-DRX test case
* Recommended WF
	+ Discuss and agree on the following.
		- Setup X2 is used in test case for fast beam sweeping.

**Issue 2-13: Test setup for dual TCI state switching**

* Proposals
	+ Option 1: (Samsung)
		- The new 3AoA setup shall be applied for dual TCI state switching TC.
			* 3 active probes should be announced
			* TDM’ing of transmissions from the AoA0 and AoA pair {AoA1, AoA2} should be assumed.
			* The maximum number of simultaneously active (emulating signal) AoA NMAX\_AoAs=2 is still satisfied under 3AoA setup assumption
	+ Option 2: (Nokia)
		- For dual TCI state switch test cases, where UE needs to switch from RS1+RS2 to RS1+RS3, three AoAs need to be defined and setup for simultaneous reception.
		- Introduce new 3 AoA setup for simultaneous reception in dual-to-dual TCI switching test cases.
		- For dual TCI state switch test cases with 3 AoA setup, where UE needs to switch from RS1+RS2 to RS1+RS3, three SSBs will be required. Additional SSB and corresponding TRS resource set configuration need to be defined for testing.
* Recommended WF
	+ Discuss and agree on the following.
		- Setup X1 is used in the test case for dual TCI state switching.

**Issue 2-14: Test setup for scheduling restriction, L1-RSRP GBBR and measurement restriction**

* Proposals
	+ Option 1: (Samsung)
		- The new 2AoA setup: both AoAs are in non Rx beam peak directions shall be applied for scheduling restriction, L1-RSRP GBBR and measurement restriction TC.
			* Suggest to assume fine beams
* Recommended WF
	+ Discuss and agree on the following.
		- Setup X2 is used in the test case for dual TCI state switching.

**Issue 2-15: test procedure for test direction and probe selection**

* Proposals
	+ Option 1: (Qualcomm)
		- Step 1: Test probe selection for {RS2, RS3}
			* A pair of directions for {RS2, RS3} is selected based on 2AoA EIS spherical coverage, which is dependent on DUT declared AoA offset as shown in Table 7.3K.3-1 of TS38.101-2.
		- Step 2: N test iterations at different pairs of test directions with respect to DUT by rotating the DUT
			* For i = 1: N iterations
				+ Step A: Rotate the DUT and select a pair of probe directions for {RS2, RS3} fulfilling 2AoA EIS spherical coverage percentile of the DUT
				+ Step B: Find a probe direction for RS1, from the two untaken probes for {RS2, RS3}, fulfilling EIS spherical coverage

If fails to find a probe for the test, go to Step A

* + - * + Step C: Proceed with the test
				+ Increase i by 1, and go to Step A
			* End
		- At each set of test directions collected from the above procedure,
			* RS1 is for anchor TRP
			* {RS2, RS3} is for
				+ R17 Group-based L1-RSRP measurements
				+ TCI state switch (either CSI-RS or SSB, not mixed-type of RSs for {RS2, RS3})
				+ Scheduling/measurement restrictions
		- The above procedure can be further simplified by RAN5, if it results in the same test coverage and suits the test purpose.
		- Assumption: TE has 4 physical probes placed at {0, 30, 90, 150} deg.
* Recommended WF
	+ Further discuss. It might be RAN5 discussion in moderator’s understanding.

**Issue 2-16: Test parameters setup**

* Proposals
	+ Option 1: (Samsung)
		- For multi-Rx test case that signals transmitted from the spherical coverage directions, the following test parameters shall be considered:
			* Data RBs allocated: 24
			* PDSCH Reference measurement channel: SR.3. 2 TDD
		- Prefer to use OCNG pattern 5 as the baseline for all the new TCs with 2AoA setup for multi-Rx simultaneous reception.
		- RAN4 to discuss whether to add a scheduling parameter to the RMC’s to specify in which slot each AoA/AoA pair can transmit/receive for multi-Rx
* Recommended WF
	+ Further discuss.

# Topic #3: Core part maintenance

### Sub-topic 1-1: Conditions for multi-RX operation and fast beam sweeping.

Background:

In last meeting, RAN4 agreed on following

* For fast beam sweeping, the UE is in multi-Rx operation if following condition is met:
	+ UE is configured with group-based beam reporting (GBBR) report.

**Issue 1-1-1: When is UE considered to be in multi-rx operation**

* Proposals
	+ Proposal 1: Keep the agreed definition
		- Given UE indication of its preference of multi-RX/single-RX operation has been allowed, it is OK to take the current definition of multi-RX operation
	+ Proposal 2: Add following additional condition
		- P2a:
			* UE sent a recent valid Rel-17 group-based beam reporting (GBBR).
			* If UE recently reported ‘Not valid’ for one of the RSRP for a beam pair, this means UE is allow to fallback to single panel for the later reception QCL-ed to that beam pair.
		- P2b: Rel-17 group-based beam reporting (GBBR) is activated/triggered by the network.
* Recommended WF:
	+ - Further discuss.

**Issue 1-1-2: End point for fast beam sweeping application.**

* Proposals
	+ Proposal 1: When multiple PDSCHs are not scheduled within 300s since group-based beam reporting is configured, the UE is allowed to exit fast beam sweeping.
* Recommended WF:
	+ - Discuss whether need to define end point.

**Issue 1-1-3: Conditions for applicability of faster beam sweeping for CBD**

* Proposals
	+ Proposal 1: Faster beam sweeping is allowed for SSB based cell specific CBD.
	+ Proposal 2: Faster beam sweeping is not allowed SSB based TRP specific CBD and CSI-RS based TRP specific CBD.
* Recommended WF:
	+ The WI was closed. Unless there is a big issue, RAN4 should not revert previous agreements.

**Issue 1-1-4: Conditions for applicability of faster beam sweeping for BFD**

* Proposals
	+ Proposal 1: Faster beam sweeping is not allowed for SSB based TRP specific BFD
* Recommended WF:
	+ The WI was closed. Unless there is a big issue, RAN4 should not revert previous agreements.

**Issue 1-1-5: Update the condition of scheduling restriction relaxation for RLM/ (cell level) BFD:**

* Proposals
	+ (From) [The CSI-RS and only one of the PDSCHs with different QCLed typeD are on the same OFDM symbol(s)]
	+ (To) The CSI-RS and both of the PDSCHs, or the CSI-RS and one of the PDSCHs with different QCL typeD when partially overlapping PDSCHs are scheduled, are on the same OFDM symbol(s)
* Recommended WF
	+ Check if they are agreeable

# References

1. R4-2408001 Topic summary for [111][204] FR2\_multiRx\_part2, Moderator (vivo)
2. R4-2408000 Topic summary for [111][203] FR2\_multiRx\_part1, Moderator (Ericsson)