**3GPP TSG-RAN WG4 Meeting # 106 R4-23XXXXX**

**Athens, Greece, 27 February –03 March, 2023**

**Agenda item:** 9.5.4

**Source:** Moderator (Qualcomm Incorporated)

**Title:** Topic summary for [106][331] FS\_NR\_FR2\_OTA\_enh

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion (e.g. list of treated agenda items) and provide some guidelines for email discussion if necessary.*

The summary is to summarize the open issues for Rel-15 OTA test maintenance and Rel-18 SI on NR FR2 OTA testing enhancements and it covers the contributions submitted under the following agendas:

* 4.6 NR MIMO OTA test methods (38.827)
* 9.5.1 General and work plan
* 9.5.2 Test methods for RF/RRM/Demodulation requirements
* 9.5.3 Test uncertainty assessments

Since there is no contribution submitted to AI 4.6, the open issues listed in following clauses are for Rel-18 SI on NR FR2 OTA testing enhancements.

# Topic #1: Test methods for RF/RRM/Demodulation

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2300087 | Qualcomm Incorporated | Proposal 1-a: RAN4 to consider including the following relative angular AoA separations: 30°, 60°, 90°, 120° and 150°.  Proposal 1-b: Additional sources in the TE shall be located so both TRPs manifest on the same constant step size AoA grid from the UE’s perspective when using constant step-size scan.  Observation 1: The legacy single TRP scan does not cover the test sphere completely with a TRP that is not in the legacy location.  Proposal 2: The TE scan strategy shall be modified to ensure 180⁰ azimuth motion per scanned hemisphere.  Observation 2: The basic 2TRP scan features AoAs that are only paired with companion AoAs in one direction but not the other. Moreover, the direction of this pairing changes in different parts of the sphere.  Observation 3: A complementary pair 2TRP scan ensures that:   1. From the UE’s perspective, both TRPs manifest on the same constant step size grid 2. Each non-pole grid point is traversed exactly twice for each TRP (once for each of two paired AoAs) 3. Each TRP covers the entire test sphere exactly twice after the complementary scan 4. The TRPs are separated by some static AoA separation 5. No missing AoA pairs (under the constraint of the test system) 6. No duplicate AoA test pairs   Proposal 3: RAN4 to consider OR combining to resolve multiple binary outcomes at the same point and harmonic mean in the mW domain to resolve multiple sensitivity outcomes at the same point.  *Moderator notes: Suggest to discussing Proposal 3 in thread [106] [131]. In this SI, we will focus on the testability issue*  Observation 4: if Proposal 1 and 2 are adopted, the system becomes rotational symmetric about the azimuth axis and blockage by the positioner mechanism is not a problem.  Proposal 4: No need to define additional test function to implement beam lock.  Proposal 5: RAN5 to choose which combination(s) of DL polarization per TRP to test for compliance verification.  Proposal 6: Take measurement setup of UE RF as the starting point for UE RRM testing. The angular separation definition should consider the progress of core requirements in RRM session.  Proposal 7: RAN4 to investigate on how to control the SINR for multi-DCI scheme.  Proposal 8: Take measurement setup of UE RF as the starting point for UE demodulation testing.  Proposal 9: RAN4 to consider Option 3 as the starting point to select the test directions for UE demodulation testing. |
| R4-2300353 | Apple | Observation 1: RAN4 is considering the possible use of an OEM declaration to determine the side condition on the fixed AoA offset.  Observation 2: Further analysis is needed to determine whether all combinations of polarization modes are needed to be emulated (i.e. VV, VH, HV, HH) or if a subset can be sufficient to verify UE performance.  Observation 3: The actual requirements (EIS-based and/or throughput-based) need to be finalized before the details of test method can be finalized. However, some initial analysis and liaising with RAN5 would help determine the best way forward with respect to UBF or other test modes.  Proposal 1: If RAN4 selects the OEM declaration approach to select the fixed AoA offset, then it is necessary to constrain the possible choices of the OEM declaration to a discrete set of parameters, thereby enabling test equipment manufacturers to validate their solutions.  Proposal 2: RAN4 should limit the polarization combinations for the verification of the FR2 multi-Rx DL requirement, with the exact combinations FFS.  Proposal 3: Send an LS to RAN5 requesting feedback on the feasibility to extend test modes such as UBF to help test the 2AoA core requirements being discussed in RAN4. |
| R4-2300763 | Anritsu Corporation | Observation 1: UBF command can control only one active FR2 UE antenna and cannot control multiple antenna panels simultaneously until Rel-17.  Observation 2: Enhancement of UBF command is not necessary for Rx spherical coverage test under multi-Rx reception condition.  Observation 3: For Tx tests, the UBF command need to be enhanced to support the simultaneous control of the antenna panels in the UE regardless with the existence of SSB or CSI-RS #0 in the DL signal.  Observation 4: There is a case that UBF is used during the Tx spherical coverage test.  Observation 5: Following functionalities for the enhanced UBF command are FFS.  - Whether to support the independent control of each UE antenna panel  - Maximum number of antenna panels to be controlled. |
| R4-2300988 | Samsung | Observation 1: 180º AoA angular separation has less signal blockage than other AoA angular separation e.g. 150º. There are only 2 test points at both poles suffering signal blockage for 180º AoA angular separation, but there are dozen of test points suffering signal blockage for 150º AoA angular separation (issue test points are {º,0º}, {º15º}, {º0º}, {º45º},……, {º º })  Observation 2: simultaneous multi-RX operation of TDD communication has no interference between active probes.  Observation 3: the signal path loss is high when signal travels from one probe to another and usually the signal level would be lower than -130dBm  Observation 4: part of the signal from one probe is scattered by the DUT and the signal from one probe reaching to another probe is further reduced  Observation 5: compared with other angular values, 180º AoA angular separation has additional advantage in terms of full-3D sampling for both AoA1 and AoA2  Observation 6: compared with other angular values, 180º AoA angular separation has additional advantage in terms of no area mismatch issue between two AoAs.  Proposal 1: maximum 0º AoA angular separation is feasible from test system capability perspective.  Proposal 2: Whether 0º and other AoA angular separation values would be adopted or not subject to RF core requirement discussion. |
| R4-2301458 | OPPO | Observation 1: Considering the network deployment scenario, the AoA angular separation of the AoA pair can hardly be 180 degree.  Proposal 1: It is not necessary to extend the AoA angular separation from 150 degree to 180 degree, from both chamber implementation and network deployment perspective. |
| R4-2301564 | vivo | Observation 1: The test point for AoA2 cannot cover the whole sphere under fixed offset setup and even fall into the gap between grid when probes are located in yz plane which may cause problem in post-processing.  Observation 2: Even under same offset value, the distribution of test points is influenced by the relative location of probe.  Proposal 1: The test probes should be fixed in the xz plane during the test.  Proposal 2: Both +/- offset with same value need to be validated for complete verification of UE performance.  Proposal 3: The down-selection of polarization pair should align with RF requirement design.  Proposal 4: If RF test system can support 3~4 probes, then it is suggested to adopt this system for RRM testing.  Proposal 5: RF test system can be reused as starting point for demodulation testing discussion. Fixed 2 AoAs is preferred.  Proposal 6: An alternative way would be that RAN4 just define a minimum isolation as criteria, and how to find test directions for 2 AoA demodulation testing is not specified. In this case, UE declaration can be considered. |
| R4-2302149 | Huawei, HiSilicon | Observation 1: Option 2a can be verified until the UE RF requirements are concluded in the core part.  Observation 2: Coverage for AoA2 is related to the angle between the AoA2 and the xy plane.  Propose 1: Angle between the AoA2 and the xy plane as large as possible is recommended to prevent the UE with poor spherical coverage of AoA2 passing the test.  Propose 2: A large offset between AoA1 and AoA2, e.g.150°/180°, can be applied for RF test to obtain large coverage of AoA2 and small interference between AoA1 and AoA2.  *Moderator notes: Suggest to discussing Proposal 2 in thread [106] [131]. In this SI, we will focus on the testability issue*  Observation 3: When a large offset between AoA1 and AoA2 are applied, the probes at different planes does not seem to have much effect on coverage of AoA2.  Propose 3: Recommend installing the probes in the horizontal plane for UE RF testing.  Propose 4: Recommend Option 2a in UE RF as the baseline for UE RRM testing.  Observation 4: For TCI switching case from dual TCI to dual TCI, it is difficult to guarantee that there are two pair of AoAs each of which can support simultaneous reception for the DUT. |
| R4-2302513 | ROHDE & SCHWARZ | Observation 1: Enhanced IFF has been proven feasible and presents clear advantages with respect to other methodologies.  Observation 2: Probe arrangement along xz plane present a better coverage of the perceived DL directions and polarizations compared to probes places in yz planes.  Observation 3: Probe arrangement along xz provide sufficient degree of freedom for test system implementation so the definition of the absolute probe locations is not required.  Observation 4: An OTA Setup 2a based on Enhanced IFF with four reflectors allows a total of 16 relevant combinations of angular separations for 2 Cells, with 2 AoA each cell.  Proposal 1: Enhanced IFF is selected as the baseline methodology (i.e. Option 2a) of multi AoA methodology for multi-Rx UEs.  Proposal 2: Probes for measurement setup Option 2a must be placed along the xz plane.  Proposal 3: Angular relationships between simultaneously active AoAs shall be reused from TR 38.810 (i.e. 30°, 60°, 90°, 120° and 150°). FFS whether only a subset of angular relationships can be defined for RF testing.  Proposal 4: For UE RRM testing the same test system design is used as for UE RF testing.  Proposal 5: For UE demodulation testing the same test system design is used as for UE RF testing. |
| R4-2302520 | Keysight Technologies UK Ltd | Observation 1: For single-probe OTA systems, different 3D UE rotation/scan options, e.g., full rotation in f (around *z* axis) and half rotation in q (around *y* axis) or full rotation in q (around *y* axis) and half rotation in f (around *z* axis), will yield the same test point coverage.  Observation 2: Probes aligned in the *yz* plane introduce large keep-out areas for the angular coverage/DL directions towards each pole.  Observation 3: With full rotation in f and half rotation in q, probes aligned in the *xz* plane introduce a conical sector towards the pole at q=0° with no angular coverage/DL directions for offset probes.  Observation 4: Constant density grids do not maintain the constant density coverage/DL direction distribution for probes offset from P0, a higher density of DL directions is observed especially near the poles.  Observation 5: When probes are aligned in the *xz* plane, constant-step size grids maintain the constant-step size distribution of DL directions for probes offset from P0.  Observation 6: Probes aligned in the *xz* plane generally provide a wider angular coverage for AoA2 DL directions when compared to probes aligned in the *yz* plane.  Observation 7: With full rotation in q and half rotation in f and probes aligned in the *xz* plane, the AoA2 DL directions are distributed in 3D without a conical region with lack of coverage.  Observation 8: Only with full rotation in q and half rotation in f, probes aligned in the *xz* plane, and constant-step size grids, uniform angular coverage/DL directions is achieved, i.e., the distribution of DL directions for all probes on the *xz* plane match the distribution of grid points.  Observation 9: When the AoA2 probes are placed in the *xz* plane, probe antenna DL q/f polarizations map to the same DUT q/f polarizations, while when AoA2 probes are placed in the *yz* plane, probe antenna DL q/f polarizations generally map to a combination of DUT q/f polarizations.  Observation 10: With probes aligned in the *xz* axis, the AoA1-AoA2 DL orientation vectors point towards the pole at q=180° for DL directions perceived from *y*≥0 while the AoA1-AoA2 DL orientation vectors point towards the pole at q=0° for DL directions perceived from *y*≤0.  Observation 11: With probes aligned in the *yz* axis, the AoA1-AoA2 DL orientation vectors point towards positive f for DL directions perceived from *y*≥0 while the AoA1-AoA2 DL orientation vectors point towards negative f for DL directions perceived from *y*≤0.  Proposal 1: Limit the maximum angular separation between probes/AoAs to 150° to avoid blocking effects, to minimize power variations inside the QZ, and allow the re-use/augmentation of existing 2 AoA RRM systems for multi-AoA UE RF testing.  Proposal 2: OEMs and chipset vendors to comment on the directionality of the AoA1-AoA2 DL orientation vectors, e.g., whether reciprocity of the TRPs will tolerate the observed directionality.  Proposal 3: For optimized AoA1 and AoA2 test point/perceived DL direction coverage, apply a full rotation in  and a half rotation in .  Proposal 4: For optimized AoA1 and AoA2 test point/perceived DL direction coverage, utilize constant-step size grids only.  Proposal 5: For optimized AoA1 and AoA2 test point/perceived DL direction coverage, place the AoA2 probes in the *xz* plane.  Proposal 6: Consider the repositioning concept with the proposed test system setup for multi-AoA RX testing to reduce the effect of blocking  Proposal 7: Limit the polarization combinations for the multi-AoA spherical coverage test case pending feedback from OEMs and chipset vendors.  Proposal 8: Consider Measurement Setup 2a the starting point for multi-AoA demodulation testing.  Proposal 9: Consider Measurement Setup 2a a suitable baseline setup for RRM testing with the number of probes FFS.  Proposal 10: The minimum number of RRM probes is pending clarifications from the requirements discussion in WI. |

## Open issues summary

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

### Sub-topic 1-1 UE RF test method

*Sub-topic description:*

*Open issues and candidate options before meeting:*

**Issue 1-1-1: Baseline method for UE RF testing**

* Proposals
  + Option 1 (R&S): Enhanced IFF is selected as the baseline methodology (i.e., Option 2a) of multi AoA methodology for multi-Rx UEs
  + Option 2: Specify other options if any
* Recommended WF
  + TBA

**Issue 1-1-2: Maximum AoA angular separation for UE RF testing**

* Proposals
  + Option 1 (Keysight, OPPO, R&S): Limit the maximum angular separation between probes/AoAs to 150°
  + Option 2 (Samsung): Maximum 180º AoA angular separation is feasible. Whether 180º and other AoA angular separation values pending on UE RF core requirements discussion
* Recommended WF
  + TBA

**Issue 1-1-3: AoAs angular separations for UE RF testing**

* Proposals
  + Option 1a (QC, Keysight): Consider relative angular AoA separations: 30°, 60°, 90°, 120° and 150°.
  + Option 1b (R&S): Consider relative angular AoA separations: 30°, 60°, 90°, 120° and 150°. FFS whether only a subset of angular relationships can be defined for RF testing.
  + Option 2 (Samsung): Consider relative angular AoA separations: 30°, 60°, 90°, 120°, 150° and [180°]
  + Option 3 (Apple): Constrain the possible choices of the OEM declaration to a discrete set of AoA angular separations.
    - *Moderator’s note: Please specify the possible choices for Option 3 if any*
* Recommended WF
  + TBA

**Issue 1-1-4: Additional sources (probes) location**

* Proposals
  + Option 1 (QC, vivo, R&S, Keysight, Huawei): Additional sources in the TE shall be located so both TRPs manifest on the same constant step size AoA grid from the UE’s perspective when using constant step-size scan. In other words, for a positioner implemented as a turn-table mounted roll motor, place the measurement probes in the plane containing the legacy source and perpendicular to the turn-table axis.
  + Option 2: Specify other option if any

*Moderator’s note: Option 1 is trying to merge companies’ proposals into a general way.*

* Recommended WF
  + TBA

**Issue 1-1-5: Turn-table and Roll motion**

* Proposals
  + Option 1 (QC): Apply a half rotation  (-90≤≤90), and ensure 180⁰ azimuth motion per scanned hemisphere
  + Option 2 (Keysight): Apply a full rotation in  and apply a half rotation in 



Figure 1.2-1: Example implementation for Turn-table and Roll-motion (R4-2302520)

* Recommended WF
  + TBA

**Issue 1-1-6: Grids for 3D scan**

* Proposals
  + Option 1 (QC, Keysight): Use constant step size grid
  + Option 2 (QC): With 180⁰ azimuth motion per scanned hemisphere, the system becomes rotational symmetric about the azimuth axis and blockage by the positioner mechanism is not a problem.
  + Option 3 (Keysight): Consider the repositioning concept with the proposed test system setup for multi-AoA RX testing to reduce the effect of blocking.
  + Option 4 (vivo, QC): Both +/- offset with same value need to be validated for complete verification of UE performance (Need to consider the directionality of the AoA1-AoA2 DL)

*Moderator’s note: The options above are not exclusive. Companies can select multiple options.*

* Recommended WF
  + TBA

**Issue 1-1-7: Polarization combinations**

* Proposals
  + Option 1 (vivo, Apple, Keysight): Limit the polarization combinations for the multi-AoA
  + Option 2 (QC): RAN5 to choose which combination(s) of DL polarization per TRP to test for compliance verification
* Recommended WF
  + TBA

**Issue 1-1-8: Additional test function**

* Proposals
  + Option 1 (QC, vivo): No need to define the additional test function
  + Option 2 (Anritsu): Enhancement of UBF command is not necessary for Rx spherical coverage test under multi-Rx reception condition. For Tx tests, the UBF command need to be enhanced to support the simultaneous control of the antenna panels in the UE regardless with the existence of SSB or CSI-RS #0 in the DL signal. Following functionalities for the enhanced UBF command are FFS.
    - Whether to support the independent control of each UE antenna panel
    - Maximum number of antenna panels to be controlled.
  + Option 3 (Apple): Send an LS to RAN5 requesting feedback on the feasibility to extend test modes such as UBF to help test the 2AoA core requirements being discussed in RAN4.
* Recommended WF
  + TBA

**Issue 1-1-9: How to handle the multiple outcome (Moved to UERF thread [106][131])**

* Proposals
  + Option 1 (QC): RAN4 to consider OR combining to resolve multiple binary outcomes at the same point and harmonic mean in the mW domain to resolve multiple sensitivity outcomes at the same point
  + Option 2: specify other option if any
* Recommended WF
  + TBA

*Moderator’s note: Suggest moving option 1 to UERF thread [106][131].*

### Sub-topic 1-2 UE RRM test method

*Sub-topic description*

*Open issues and candidate options before meeting:*

**Issue 1-2-1: Measurement setup for RRM testing**

* Proposals
  + Option 1 (QC, vivo, Huawei, R&S, Keysight): Reuse the same test system design of UE RF testing for UE RRM testing as the starting point. The number of probes is FFS depending on the RRM session progress.
  + Option 2: TBA
* Recommended WF
  + Option 1

**Issue 1-2-2: Test parameters for RRM testing**

* Proposals
  + Option 1 (QC): RAN4 to investigate on how to control the SINR for multi-DCI scheme.
  + Option 2: TBA
* Recommended WF
  + TBA

### Sub-topic 1-3 UE Demodulation test method

*Sub-topic description*

*Open issues and candidate options before meeting:*

**Issue 1-3-1: Measurement setup for demodulation testing**

* Proposals
  + Option 1 (QC, vivo, R&S, Keysight): Reuse the same test system design of UE RF testing for UE demodulation testing as the starting point. The two AoAs are fixed during the testing.
  + Option 2: TBA
* Recommended WF
  + Option 1

**Issue 1-3-2: Test directions for demodulation testing**

* Proposals
  + Option 1 (QC): The test directions selected should ensure UE passing legacy REFSENSE requirements with XdB degradation per branch in addition to the minimum isolation for all the active branches.
  + Option 2 (vivo): RAN4 just define a minimum isolation as criteria, and how to find test directions for 2 AoA demodulation testing is not specified. In this case, UE declaration can be considered.
* Recommended WF
  + TBA

# Topic #2: Test uncertainty assessments

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2302148 | Huawei, HiSilicon | Proposal 1: For IFF setup, uncertainty contributions in Table B.19.2-1 of TP38.903 are baseline for multi-Rx test system and some uncertainty elements need to be reassessed due to two AoAs. |

## Open issues summary

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

### Sub-topic 2-1 Uncertainty assessments

*Sub-topic description:*

*Open issues and candidate options before meeting:*

**Issue 2-1: Uncertainty assessments**

* Proposals
  + Option 1 (Huawei): For IFF setup, uncertainty contributions in Table B.19.2-1 of TR 38.903 are baseline for multi-Rx test system and some uncertainty elements need to be reassessed due to two AoAs.

Table B.19.2-1: Uncertainty contributions for EIS measurement from TR 38.903

| UID | Description of uncertainty contribution | | comments |
| --- | --- | --- | --- |
| Stage 2: DUT measurement | | | |
| 1 | Positioning misalignment | | Reuse(=0) |
| 2 | Measure distance uncertainty | | Reuse(=0) |
| 3 | Quality of Quiet Zone | | Reuse(=0.6) |
| 4 | Mismatch | | Consider two AoAs |
| 5 | Standing wave between the DUT and measurement antenna | | Reuse(=0) |
| 6 | gNB emulator uncertainty | | Reuse(=2.9) |
| 7 | Phase curvature | | Reuse(=0) |
| 8 | Amplifier uncertainties | | Consider two AoAs |
| 9 | Random uncertainty | | Consider two AoAs |
| 10 | Influence of the XPD | | Consider two AoAs |
| 11 | Insertion Loss Variation | | Reuse(=0) |
| 12 | RF leakage (from measurement antenna to the receiver/transmitter) | | Reuse(=0) |
| 13 | Multiple measurement antenna uncertainty | | Consider two AoAs |
| 14 | DUT repositioning | | Reuse(=0/0.08) |
| 15 | | Influence of spherical coverage grid | FSS |
| Stage 1: Calibration measurement | | | |
| 16 | Mismatch | | Reuse(=0) |
| 17 | Amplifier Uncertainties | | Reuse(=0) |
| 18 | Misalignment of positioning System | | Reuse(=0) |
| 19 | Uncertainty of the Network Analyzer | | Reuse(=0.73) |
| 20 | Uncertainty of the absolute gain of the calibration antenna | | Reuse(=0.6) |
| 21 | Positioning and pointing misalignment between the reference antenna and the measurement antenna | | Reuse(=0.01) |
| 22 | Phase centre offset of calibration antenna | | Reuse(=0) |
| 23 | Quality of quiet zone for calibration process | | Reuse(=0.4) |
| 24 | Standing wave between reference calibration antenna and measurement antenna | | Reuse(=0) |
| 25 | Influence of the calibration antenna feed cable | | Reuse(=0.14) |
| 26 | Insertion Loss Variation | | Reuse(=0) |
| Systematic uncertainties | | | |
| 27 | | Systematic error related to beam peak search | FSS |
| 28 | | Systematic error related to EIS spherical coverage | FSS |

* + Option 2: Specify the option if any
* Recommended WF
  + TBA

# Topic #3: TPs to TR 38.871

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Title** |
| R4-2300085 | Qualcomm Incorporated | 3GPP TR 38.871 V0.1.0  =>For email approval |
| R4-2300086 | Qualcomm Incorporated | TP on TR 38.871 for editorial correction and general aspects |
| R4-2302150 | Huawei, HiSilicon | TP on TR 38.871 calibration measurement procedure |
| R4-2302521 | Keysight Technologies UK Ltd | TP to introduce Multi-AoA UE RF Test Aspects |