**3GPP TSG-RAN WG4 Meeting #95-e R4-2009047**

**Electronic Meeting, 25 May – 5 June, 2020**

**Agenda item:** 9.1.1

**Source:** Moderator (CAICT)

**Title:** Email discussion summary for [95e][326] FS\_NR\_MIMO\_OTA\_test

**Document for:** Information

# Introduction

Based on the agreed WF [1], FR2 MIMO OTA remaining open issues on PSP validation and QoQZ shall be finalized this meeting:

*Remaining Open issues：*

* + ***FR2 PSP Validation procedures***
		- *CE vendors align on the PSP validation procedure before next RAN4 e-meeting, e.g.,*
			* *consider if Roll/AZ positioner could be used for SP method [R4-2005560]*
			* *consider different virtual array configurations and NF compensation methods for the PAS estimation step for KS method [R4-2004565]*
		- *If misalignment still shows next meeting, then better accuracy vs. measurement time will be the KPI to select one procedure to finalize this topic.*
	+ ***FR2 QoQZ procedure***
		- *QoQZ procedure based on the agreed 6 probes location shall be finalized next RAN4 e-meeting*

In addition, the maintenance of Rel-15 NR UE Testability TR38.810 (i.e. FR2 test methods for UE RF, RRM and Demod) is also discussed in this email thread.

List of candidate target of discussion for 1st round and 2nd round

* 1st round: make decision on PSP and QoQZ validation procedure.
* 2nd round: finalize the content of TPs based on the decision of 1st round.

# Topic #1: FR2 test methods

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2006308 | CAICT | **TP to TR 38.827 v1.3.0 on RMC correction** |
| R4-2006431 | Samsung | **Proposal 1: feasible SNR range can be split into two parts: single probe contribution (SNRsingle-probe) and multi-probe contribution (ΔSNRmulti-probe), i.e., SNR3D-MPAC = SNRsingle-probe + ΔSNRmulti-probe****Observation 1: the multi-probe SNR contribution (ΔSNRmulti-probe) is affected by two aspects, probe weights at TE side and antenna directivity pattern at UE side.****Observation 2: the multi-probe SNR contribution (ΔSNRmulti-probe) is expected in the range of [0, 3.5]dB.****Proposal 2: it is encouraged for TE vendors to input an aligned estimated value to ΔSNRmulti-probe among [0, 3.5]dB based on probe weights for CDL-A InO and CDL-C UMi respectively** |
| R4-2006740 | Keysight Technologies | **Observation 1: Suitable omnidirectional loop and dipole reference antennas with insignificant azimuth gain variations currently do not exist.****Observation 2: The current FR1 QoQZ procedure cannot be leveraged for the NR FR2 3D MPAC QoQZ validation procedure.****Observation 3: For NR MIMO OTA, only the single-directional EIRP/EIS metrics need to be assessed in the QoQZ procedure****Observation 3: The existing NR FR2 QoQZ validation approach is suitable for NR FR2 3D MPAC systems****Proposal 1: Leverage the NR FR2 UE RF QoQZ procedure for NR FR2 3D MPAC MIMO OTA systems using just a single measurement probe****Proposal 2: Include the draft text below as FR2 QoQZ Validation procedure in [6].** |
| R4-2006741 | Keysight Technologies | **Observation 1: The two-step process using the MUSIC algorithm shows PSP of >96% when the OTA PAS is considered the reference.****Observation 2: The PSP results using the spatial correlation-based approach are not as good as with the MUSIC based approach.****Proposal 1: Adopt the PSP validation approach based on a virtual antenna array configuration with two vertical sectors and one horizontal sector and the MUSIC algorithm.** |
| R4-2006742 | Keysight Technologies, Spirent Communications | **TP to 38.827 to add PSP validation procedure** |
| R4-2006743 | Keysight Technologies | **Observation 1: The current FR2 3D MPAC system definition has ambiguities in terms of UE positioning and the NR MIMO probes****Observation 2: The spherical coordinate system lends itself to a common ambiguity which could be avoided by limiting rotation angles to certain ranges.****Observation 3: Whether the UE is rotated so that the test direction w.r.t. to the UE is aligned with the channel model coordinate system z axis or whether the UE is rotated so that the z axis of the UE’s coordinate system is aligned with the fixed test point w.r.t. the channel model coordinate system will yield additional ambiguities.****Observation 4: Option 1 introduces the least amount of positioner blockage while Options 2 and 3 can obstruct the path between UE and NR MIMO probes.****Proposal 1: Select a single positioner, probe layout configuration, and rotation assumption to avoid ambiguities****Proposal 2: Select Option 4 of the FR2 NR MIMO system configuration as the baseline for 3D MPAC systems.****Proposal 3: Perform the UE rotations based on the assumption that the test direction w.r.t. to the UE is aligned with the channel model coordinate z axis****Proposal 4: Limit the turntable rotation to a range of 0 to 180o only.** |
| R4-2007085 | OPPO | **Proposal:** to realize the placement of FR2 uplink communication path in MPAC, two approaches could be considered:* Add an independent antenna near the 6 downlink probes
* Pick up the uplink signals from one or several of the 6 probes

Consequently, in order to guarantee the FR2 3D-MPAC system working effectively, the following aspects is FFS.* The dynamic range of uplink signal
* The isolation between downlink and uplink
 |
| R4-2007592 | Spirent Communications | **Observation 1**. PSP validation most likely need some phase taper correction technique.**Observation 2.** If the number of measurement time is limited, number of virtual elements will also become limiter mandating to use some super-resolution technique to estimate DoA.**Proposal 1.** Apply either of the PSP validations proposed in [1],[2], using super-resolution technique to estimate DoA. |
| R4-20007594 | Spirent Communications | TP on Verification of Channel Model implementation in TR38.827, PSP |
| R4-2007658 | ROHDE & SCHWARZ | **Observation 1**: Current probe layout centered around 90º elevation and close to 0º azimuth will affect the DUT performance.**Observation 2**: Simulations to evaluate the PSP performance implement a rotation of the DUT so the original absolute impinging angles of each channel model are respected.**Proposal:** Channel model rotations shall be specified in TR 38.827 and FR2 test points shall be rotated to compensate them on a per channel model basis.  |
| R4-2008273 | Keysight Technologies | **TP to TR38.827 to avoid ambiguities for FR2 MIMO OTA Testing** |

## Open issues summary

### Sub-topic 1-1 FR2 PSP validation procedure

* Proposals
	+ - **Proposal 1.** Apply either of the PSP validations proposed in [1],[2], using super-resolution technique to estimate DoA.
		- **Proposal 2:** Adopt the PSP validation approach based on a virtual antenna array configuration with two vertical sectors and one horizontal sector and the MUSIC algorithm

Related TPs: R4-20007594 and R4-2006742

* Recommended WF
	+ Make decision on PSP validation procedure and text proposal

### Sub-topic 1-2 FR2 QoQZ procedure

* Proposals
	+ **Proposal 1:** Leverage the NR FR2 UE RF QoQZ procedure for NR FR2 3D MPAC MIMO OTA systems using just a single measurement probe.
	+ **Proposal 2:** Include the draft text below as FR2 QoQZ Validation procedure in [6].
* Recommended WF
	+ Make decision on QoQZ procedure and corresponding text proposal.

### Sub-topic 1-3 other FR2 system issues

**Issue 1-3-1: 3D-MPAC SNR analysis**

* Proposals
	+ **Proposal 1: feasible SNR range can be split into two parts: single probe contribution (SNRsingle-probe) and multi-probe contribution (ΔSNRmulti-probe), i.e., SNR3D-MPAC = SNRsingle-probe + ΔSNRmulti-probe.**
	+ **Proposal 2: it is encouraged for TE vendors to input an aligned estimated value to ΔSNRmulti-probe among [0, 3.5]dB based on probe weights for CDL-A InO and CDL-C UMi respectively**.
* Recommended WF
	+ TBA

**Issue 1-3-2: UE orientations in 3D-MPAC system**

* Proposals
	+ **Proposal 1: Select a single positioner, probe layout configuration, and rotation assumption to avoid ambiguities**
	+ **Proposal 2: Select Option 4 of the FR2 NR MIMO system configuration as the baseline for 3D MPAC systems.**
	+ **Proposal 3: Perform the UE rotations based on the assumption that the test direction w.r.t. to the UE is aligned with the channel model coordinate z axis**
	+ **Proposal 4: Limit the turntable rotation to a range of 0 to 180o only.**
	+ **Proposal 5:** Channel model rotations shall be specified in TR 38.827 and FR2 test points shall be rotated to compensate them on a per channel model basis.
* Recommended WF
	+ TBA

**Issue 1-3-3: FR2 Uplink path**

* + **Proposal: to realize the placement of FR2 uplink communication path in MPAC, two approaches could be considered:**
		- Add an independent antenna near the 6 downlink probes
		- Pick up the uplink signals from one or several of the 6 probes
* Recommended WF
	+ TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Sub topic 1-1: * Clarification questions on R4-2006741:
	+ The real antenna array might be different from the assumption in the PSP validation procedure, i.e. 4\*4, how the does antenna array impact the real PSP values in the testing?
	+ Is PSP limit different with frequency carrier?
* The PSP validation procedure should make sure the PSP in real test is comparable with the target PSP limit when deciding the probe layout.

Sub topic 1-2:* Leveraging NR FR2 UE RF QoQZ procedure for NR FR2 3D MPAC MIMO OTA systems makes sense.

Sub topic 1-3:* Issue 1-3-1: Agree with Samsung’s analysis on proposal 1. For observation 2, considering UE antenna array depends on UE implementation, we prefer to use [0, 7.8]dB as the starting point. Input on SNR gain is encouraged from TE vendors considering typical UE antenna assumptions such as 1\*4, 2\*4.
* Issue 1-3-2: Clarification question on proposal 4, with limitation on the turntable rotation from 0 to 180, can it still guarantee 3D test directions are covered? Does it mean there is no need to do the re-positioning with option 1 or option 4?

Issue 1-3-3: |
| Samsung | Sub topic 1-3: other FR2 system issues* Issue 1-3-1: 3D-MPAC SNR analysis
	+ Thanks Qualcomm’s comments. Agree that [0, 7.8]dB is the starting point. Input on SNR improvements from multi-probe (**ΔSNRmulti-probe**) is encouraged from TE vendors considering typical UE antenna assumptions such as 1\*4, 2\*4 and considering beam weights for CDL-A InO and CDL-C UMi respectively.
* Issue 1-3-2: UE orientations in 3D-MPAC system
	+ We support Keysight’s proposal 1 and proposal 2. It is beneficial to avoid ambiguity by standardized relative location among positioner, probe and UE. Option 4 helps to minimize the positioner blocking effect.
* Issue 1-3-3: FR2 Uplink path
	+ Thanks OPPO for raising the uplink path issue. It is necessary to make it clear. For the approach of “Add an independent antenna near the 6 downlink probes”, not sure if there will be testability issue especially for UEs with narrow beam like power class 1.
 |
| CAICT | Sub topic 1-1: In R4-2006742, regarding the Semi-circle measurement array configurations in Figure 7.4.1.6-1, are these two options for selection or both shall be done for validation? If anyone is OK, suggest to align with the discussion paper using “Two alternative semi-circle measurement array configurations with N = 37 elements (at 28 GHz). On the left with two crossed vertical sectors, on the right with two parallel vertical sectors.” Sub topic 1-2: Agree with the proposals.Sub topic 1-3:* Issue 1-3-1: agree with this approach. From the experience of FR1 MIMO OTA measurement, the maximum DL power is the main critical aspect for the whole system. So suggest to calculate the SNR or at least SNR range for FR2 at early stage, which is good for us to continue our work in the next step.
* Issue 1-3-2:
* Issue 1-3-3: we need to check whether there is an isolation issue, if we reuse the downlink path for uplink.
 |
| R&S | Sub-topic 1-1 FR2 PSP validation procedure* Similar to Qualcomm’s comments above, we are concerned about how comparable are the results from the proposed PSP validation procedures with the simulations used to decide the probe layout. More precisely, the proposed radius in R4-2006741 is R = 5cm corresponding to half the test volume size of R = 10cm. As shown in figures and results in R4-2006741, all PSP results are better compared to the ones presented last meeting.
* Even though the proposed procedures are very much detailed, there is no clear information about the test antenna to be used, what is an essential element. More details are required.

Sub-topic 1-3 other FR2 system issuesIssue 1-3-2 (UE orientation in 3D-MPAC system)* Comments on Keysight’s R4-2006743:
	+ We do not agree with several of the observations along the document where there is a “lack of definition how the UE rotations need to be performed” since theta/phi rotations are clearly defined in TR 38.827, clause A.1.
	+ Option 1 along the document does not respect the theta/phi rotations defined in the reference coordinate system.
	+ Regarding Proposal 2, it describes a very concrete implementation of the positioning system, while the same issues can be solved in different ways depending on the positioning system. Therefore we cannot agree to it. Same comment applies to Proposal 4. How this potential issues are solved should be left to test system implementation.
	+ Proposal 3 refers the alignment of UE with respect to the channel model z-axis (thus in elevation), but does not address the required additional adjustment on the test points due to the change in azimuth.
* Since the DUT alignment to the reference coordinate system (including the corresponding rotations in theta/phi), the test points and the probe locations are already defined in the technical report, the only missing parameters are the channel model rotations to fit the probe locations. With those, DUT test points can be adjusted in theta/phi per channel model in the same way the rotations were compensated on the simulations for PSP performance.
 |
| Qualcomm | Sub topic 1-3:Issue 1-3-3: We agree with OPPO’ proposal that the position of FR2 UL path should be discussed. We should note that UE BC depends on certain SNR side condition. In other words, to make sure UE can keep the uplink connection with the same direction as DL beam, SNR side condition should be guaranteed. |
| Keysight | Sub topic 1-1: * **Response to QC:**
	+ as discussed in earlier meetings, all FR2 PSP simulations presented so far have been based on the 4x4 Bartlett beamformer. Non-symmetric arrays such as 4x1 or 4x2 cannot be used in probe placement optimization simulations with the black box approach; here it necessary to use symmetric arrays.
	+ Since the 4x4 antenna array was used for PSP simulations deciding the probe placements, the suggestion here is to use the same assumption for PSP validation.
* **Response to CAICT:**
	+ Two configurations were introduced since different positioner/coordinate system definitions will yield either two parallel scans or an X scan, e.g., Options 1, 2, 3 of R4-2006743. If we limit the options, we could focus on just a single vertical scan but we can further revise the TP to align with the discussion paper, no problem.
* **Response to R&S:**
	+ The reasons for the better results are due to various changes when compared to last meeting, e.g., optimized virtual array configuration and near-field compensation method.
	+ The most suitable approach for the PSP validation is based on an omnidirectional antenna (omni in AZ and wide BW in EL) as the test can be automated easily. Alternatively, a directional antenna could be used but requires frequent re-positioning.

Sub topic 1-3:* Issue 1-3-1:
* Issue 1-3-2:
	+ **Response to R&S:**
		- As outlined in the contribution, different interpretations to theta/phi test directions are possible and we are asking to clearly define those. While in OTA systems with a single, dedicated measurement probe, theta/phi usually corresponds to either UE or probe antenna rotations, we felt that NR FR2 MIMO OTA requires additional clarifications. Can you confirm that you can agree with Proposal 3 then which clearly ties theta/phi to UE rotations?
		- It is not clear to us why Option 1 does not respect theta/phi rotations, we feel the example rotations indicate it is a viable option
		- If we do not define a specific implementation (P2) and turntable rotations (P4), we are afraid that there will be ambiguities and that different system implementations will yield different results and that different pass/fail verdicts can be reached. We feel option 4 is the best compromise in terms of ambiguities, blocking, and coordinate system familiarity.
* Issue 1-3-3:
	+ We believe UL link antenna placement should be left to system vendors similar to UE RF systems.
 |
| MVG | Sub topic 1-1: * In the response from KS to RnS, near field compensation was used in order to derive PSP results. What kind of near field compensation? Is this compensation based on Spherical Wave Expansion (SWE) algo? Does it require to measure the phase in NF at the DUT during the validation process? In FR1, spatial correlation was calculated based on relative power measurement. NF phase was not needed.
* R4-2006741 – I think this was a comment from other companies too but we are not sure what type of antenna to be used for PSP validation. Usually, for calibration and system validation reference antenna (from different manufacturers) could be used. Those antennas come with test report and eventually calibration report. It means the characteristics of the antenna could be easily understood. Is there a way the used antenna can be documented? In terms of the radiating properties?
 |

### CRs/TPs comments collection

*NR MIMO OTA is a close-to-finalize SI, suggest to focus on finalizing the text proposals for TR.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| R4-2006308 | *Samsung: Thanks CAICT, we support this TP.* |
| R4-2006740 |  |
|  |
| R4-2006742 |  |
|  |
| R4-2007594 |  |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic 1-1** **FR2 PSP validation procedure** | *Tentative agreements:* * Develop PSP validation procedure based on the proposals in R4-2006742 as baseline.

*Recommendations for 2nd round:** Refine the wording of PSP validation procedure to address the comments from 1st round. Focus on the TP discussion and finalize the content in 2nd round.
 |
| **Sub-topic 1-2** **FR2 QoQZ procedure** | *Agreements:* * + **Proposal 1:** Leverage the NR FR2 UE RF QoQZ procedure for NR FR2 3D MPAC MIMO OTA systems using just a single measurement probe.
	+ **Proposal 2:** Include the draft text below as FR2 QoQZ Validation procedure in [6].

*Recommendations for 2nd round:** None
 |
| **Sub-topic 1-3** **other FR2 system issues** | **Issue 1-3-1: 3D-MPAC SNR analysis** *Tentative agreements:* * + **Proposal 1: feasible SNR range can be split into two parts: single probe contribution (SNRsingle-probe) and multi-probe contribution (ΔSNRmulti-probe), i.e., SNR3D-MPAC = SNRsingle-probe + ΔSNRmulti-probe.**

*Recommendations for 2nd round:** Further discuss **ΔSNRmulti-probe**, proper range value is encourage to be stabilized in 2nd round.

**Issue 1-3-2: UE orientations in 3D-MPAC system** *Tentative agreements:**Recommendations for 2nd round:** Further discuss on this topic.

**Issue 1-3-3: FR2 Uplink path** *Tentative agreements:* * + Suitable uplink path of FR2 MIMO OTA system shall be considered

*Recommendations for 2nd round:** Further discuss if we need to standardize the UL antenna placement, or leave this open for different system implementation.
 |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| #1 | WF on FR2 MIMO OTA | CAICT |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| R4-2006308 | *Agreeable* |
| R4-2006740 | *Agreeable* |

## Discussion on 2nd round

### Sub-topic 1-1 FR2 PSP validation procedure

*Tentative agreements:*

* Develop PSP validation procedure based on the proposals in R4-2006742 as baseline.

*Recommendations for 2nd round:*

* Refine the wording of PSP validation procedure to address the comments from 1st round. Focus on the TP discussion and finalize the content in 2nd round.

### Sub-topic 1-3 other FR2 system issues

**Issue 1-3-1: 3D-MPAC SNR analysis**

*Tentative agreements:*

* + **Proposal 1: feasible SNR range can be split into two parts: single probe contribution (SNRsingle-probe) and multi-probe contribution (ΔSNRmulti-probe), i.e., SNR3D-MPAC = SNRsingle-probe + ΔSNRmulti-probe.**

*Recommendations for 2nd round:*

* Further discuss **ΔSNRmulti-probe**, proper range value is encourage to be stabilized in 2nd round.

**Issue 1-3-2: UE orientations in 3D-MPAC system**

*Tentative agreements:*

*Recommendations for 2nd round:*

* Further discuss on this topic.

**Issue 1-3-3: FR2 Uplink path**

*Tentative agreements:*

* + Suitable uplink path of FR2 MIMO OTA system shall be considered

*Recommendations for 2nd round:*

* Further discuss if we need to standardize the UL antenna placement, or leave this open for different system implementation.

|  |  |
| --- | --- |
| **Company** | **Comments for 2nd round** |
| Qualcomm | Issue 1-3-1: 3D-MPAC SNR analysis: The input from TE vendors on **ΔSNRmulti-probe** corresponding to probe weights for CDL-A and CDL-C are encouraged.Issue 1-3-2: UE orientations in 3D-MPAC system: We support to solve the ambiguities otherwise the relative orientations between UE and agreed probes layouts will be different. Issue 1-3-3: FR2 Uplink path: Clarification questions: Without standardization for UE antenna placement, how to make sure DUT can keep the uplink connection or how to guarantee there is no issue for uplink during the testing? |
| Keysight | **Response to MVG On Topic 1-1:*** The MUSIC algorithm uses array steering vectors in the estimation. The virtual measurement array has such large aperture that probes are in its near field and to mitigate this problem, we utilize the a priori information of the range length R, i.e., the distance from each probe to the centre of test zone which must be also the centre of arches of the virtual array. With this information the normal DFT steering vectors ω(θ,φ) are substituted by vectors determined using the distance ω'(θ,φ,R). Here, we are making three assumptions which we believe are correct for NR FR2 MIMO OTA systems: 1) the range length information is sufficient accurate, 2) all probes have the same distance to the test zone centre, 3) the centre of test zone is the centre of the virtual measurement array. The PSP algorithm utilizes magnitude and phase measurements as outlined in Step 2 of the PSP validation procedure
* The types of antenna that can be used for the PSP validation can be clarified in the revised draft of the PSP validation procedure (similar to what I outlined in round 1 discussions). More details of the antennas could be specified in the WI phase when more measurements have been performed with sample antennas. After reviewing the FR1 CM validation procedures, it seems that those validation antennas do not have any specifications either.

**Response to QC:** * Issue 1-3-1: we do not have any concrete feedback regarding ΔSNRmulti-probe at this point
* Issue 1-3-3: the UL path is an uncalibrated path and has not been standardized for any other FR2 system, i.e., UE RF, Demodulation, RRM. The UL path has not been standardized for FR1 MIMO OTA either. Different vendors have different approaches for implementing the UL path, e.g., NF coupling probes vs probes in the FF, single vs multiple probes, dynamic switching between probes, etc. We believe there is no need to standardize the UL path for NR FR2 MIMO.

Issue 1-3-2: We believe it is very important to avoid any ambiguities as different test systems will yield different measurement results otherwise and therefore potentially different pass/fail verdicts. It seems R&S does not believe Option 1 is a viable option (we believe it is); can you confirm that R&S prefers Option 2 or are there any concerns with the Roll-over-Az positioner architecture? Since we would prefer Option 2 with a 90deg rotation of the probes in AZ, maybe we find a suitable compromise? Does R&S have concrete suggestions to avoid the ambiguities as the DUT fixture suggested in R4-2007658 does not prevent the ambiguities.  |
| R&S | **Response to Keysight on sub-topic 1-1 (FR2 PSP validation):*** Following the response for 1st round, our comment about the better PSP results was referred to the results between the Theoretical Reference and the simulated OTA. They are way better compared to the results presented during past meeting that were used to decide on the probe layout, and we assume this is due to the reduced radius proposed for the PSP validation (5cm instead of 10cm). Could you please clarify why the PSP validation cannot be performed much closer to the actual test volume size, instead of just the half?
* Regarding the test antenna we appreciate the additional details provided, but it is still not clear how the 2 polarizations are to be tested assuming that the omnidirectional antenna (omni on AZ and wide BW on EL) is single polar.

**Response to Keysight on Issue 1-3-2 (UE orientations in 3D-MPAC system):*** Follow-up on the response for 1st round:
	+ It is not clear how Proposal 3 solves any ambiguity, but it seems we are not far from alignment here. In our view, how DUT shall be rotated for the test points is already clear in TR 38.827 but the problem comes from the “commodity” of rotating the channel model to make it easier to implement with physical probes. By compensating the test points with the channel model rotations, we’re actually proposing to align x-y-z axes to the channel model.
	+ Regarding Option 1 in R4-2006743, it can be clearly seen that theta rotations at phi = 0 cannot be achieved, so it doesn’t respect the coordinate system in TR 38.827.
	+ In our view, if the coordinate system, DUT alignment to coordinate system, probe locations and channel model rotations are defined, there are no ambiguities and how the final test system respect all those is due to system implementation.
* On the comments for the 2nd round:
	+ If we want to solve any ambiguity between different test systems, we should also fix things like channel model rotations, probe weights, test distance… but these are all left to system implementations to allow different providers.
	+ There is no DUT fixture suggested in R4-2007658 since this is system implementation dependent. Figures in that contribution show the relative orientation between reference coordinate system, DUT alignment and channel model.
	+ What are Keysight concerns to the simplest solution provided in R4-2007658? i.e.: “Channel model rotations shall be specified in TR 38.827 and FR2 test points shall be rotated to compensate them on a per channel model basis.”
* As a way forward, and assuming that the group shall not limit the positioning system implementation to a single one, we see 2 clear options:
1. We agree to Proposal 5 from the list (i.e.: compensate test points according to channel model rotations) and we further clarify how UE rotations are performed, similar to what is proposed in Proposal 3 from the list.
2. We keep everything as it is (including fixed probe location around 90º elevation and 0º azimuth) assuming that test results might not represent actual UE orientations with respect to the original channel model. The effect of this option is minimized by the fact of having 36 points evenly distributed over the sphere.

As a complement to either of these 2 options, the proposed 90º rotation of the probes in AZ might also help resolve some of the ambiguities highlighted in R4-2006743.**Comments on Issue 1-3-3 (FR2 Uplink path)**: We think UL antenna placement should be left to system implementation, but we already presented a few meetings ago this issue (R4-1911807) and how the UL path could be made stable by using the UL (or Tx only) UE Beamlock Function.  |
| Keysight | **Response to R&S:****Topic 1-1*** Reducing the radius of the virtual array/test point configuration allows a significant reduction of test points and thus test time which was raised as concern in the last meeting. We believe this reduced radius of 5cm allows a good compromise of test time and PSP validation efficiency.
* Performing the PSP validation using two polarizations would only be feasible by using a directional antenna and testing in both principle orientations. Due to the lack of commercially available loop antennas in mm-wave frequency range, we propose to limit the PSP validation to just the vertical polarization. In LTE, the FR1 spatial correlation validation was required for the vertical polarization only. It is not clear why both polarizations are required for FR1 spatial correlation in 38.827 but our proposal is to limit PSP validation to vertical polarization only; at the same time, we suggest to limit FR1 spatial correlation to vertical polarization as well. Feedback from the group would be appreciated.

**Topic 1-3-2*** The following illustration of an even simpler example than those shown in R4-2006743 will hopefully further demonstrate our concerns with the ambiguities even better. Here, a test point direction of (theta=90o, phi=0o) is selected, i.e., x axis with respect to the UE coordinate system. The test point (black dot) is shown in the first row for Options 1 and 2. In the second row, we show one device/positioner rotation that will align the x axis of the UE with the z axis of the global channel model coordinate system. Clearly, when comparing the relative UE directions in the second row between Options 1 and 2, you see an obvious ambiguity, i.e., for Option 1, the right side of the UE is facing the probes and the positioner is not blocking the measurement path while for Option 2, the bottom of the device is facing the probes and the positioner is blocking the measurement path. The third row shows an alternate UE/positioner rotation that also aligns the x axis of the UE with the z axis of the channel model coordinate system. For Option 1, the left side of the UE is now facing the probes while for Option 2, the top of UE is now facing the probes. In either case, the positioner is not blocking the measurement path. These examples clearly show 4 potential completely different UE directions with respect to the NR MIMO probes for the same test direction of (theta=90o, phi=0o). This is exactly what we are trying to avoid with our Proposals 2, 3, and 4.

We hope this illustration is very clearly demonstrating that even when we agree on the UE rotation assumption (Proposal 3), various ambiguities can be noted which can be avoided completely with Proposals 2 and 4. We also hope that this simple example illustrates why R&S’ proposal “FR2 test points shall be rotated to compensate them on a per channel model basis” does not solve the ambiguity issues highlighted above, e.g., what if the test point after compensating the channel model rotation ends up to be (theta=90o, phi=0o). This compensation will subsequently yield the same situation outlined in the simple example below.

|  |
| --- |
| **Sample Test Point Direction #3 (theta=90o, phi=0o) for different FR2 3D MPAC MIMO OTA Implementations assuming the UE is rotated so that the test direction w.r.t. to the UE is aligned with the channel model coordinate z axis** |
| **Probe Orientation** | **Option 1** | **Option 2** |
| **Illustration of Test Point #3** |  |  |
| **After UE/positioner rotation so that test direction (x axis) w.r.t. to the UE is aligned with the channel model coordinate z axis**  |  |  |
| **After alternate UE/positioner rotation so that test direction (x axis) w.r.t. to the UE is aligned with the channel model coordinate z axis** |  |  |

* The intent with Proposal 3 is to define the UE rotations once and for all. While the coordinate system is defined, we don’t believe that the UE rotations are clear, especially for people that are more familiar with channel modelling than with OTA. The two different examples in our contribution outline two different options that we can think of (based on how OTA people and channel emulation people approach rotations). The one major difference for FR2 MIMO OTA when compared to other OTA systems is that there is no measurement probe in the test direction. Proposal 3 would clearly specify how the UE would be rotated which is aligned with how we would typically do it in OTA. Without this definition, we don’t believe that those rotations would be clear to everyone.
* Regarding your comment: “Regarding Option 1 in R4-2006743, it can be clearly seen that theta rotations at phi = 0 cannot be achieved, so it doesn’t respect the coordinate system in TR 38.827” It seems you are saying that test points location on the xz plane cannot align with the z axis of the channel model coordinate system which we do not agree with as illustrated in the simple example above. When you perform a 90deg roll of the device with Option 1, you will subsequently be able to sample the xz plane with AZ rotations between -180 and +180deg. If you don’t believe theta rotations at phi=0 can be achieved with Option 1, I believe that the same would apply for theta rotations at phi=90 and Option 2. I acknowledge that Option 1 is untypical for OTA systems since they usually define the y axis to be aligned with the turntable axis; however, we don’t see any reason why Option1 would not be applicable here. As we outlined in our contribution, we believe that Option 1 is the most suitable approach taking blocking effects into account. If the NR MIMO probes can be rotated by an additional 90deg, Option 4 becomes the more suitable approach.
* If we agree on the UE rotations (per Proposal 3), we have highlighted two different ambiguities in our contribution: one related to Option 1 vs Option 2 and one related to the spherical coordinate system without limiting the ranges of motion (Observation 1 and Figure 1 in our contribution); they are also highlighted in the simple example above. It is not clear how R&S plans to address those if we don’t agree to limit the options and range of motion. We believe that the coordinate system is defined in A.1 of 38.827 (specifically A.1-1), the DUT alignment to coordinate is defined in A.1 of 38.827 (specifically A.1-2), the probe locations are defined in 6.2.3 in 38.827, and we have no reservations on adding the channel model rotations. However, as outlined in our contribution, the 3D test points will still yield ambiguities without properly defining the range of motion (our P4) and the system configuration (our P1 and P2). We don’t see how compensating the test point directions by the fixed channel model rotation is avoiding the ambiguities we have highlighted.
* Regarding R&S comment that different probe weights, test distances, and channel model rotations can introduce ambiguities. We believe that the channel model rotations are fixed, and we agree to specify them in the TR. If the probe weights between vendors are not aligned, this would likely result in differences in the channel model validation results and there would need to be corrected. I believe that all CE vendors previously agreed not to share probe weights. Limiting the test distance could be an option to avoid differences in measurement results but the test distance and probe weights obviously do not introduce ambiguities we agreed to study in the last WF with respect to test directions. I should also point out that we have not limited the test distance to one fixed test distance for any MIMO OTA testing before.
* I agree that R4-2007658 does not specifically call out a DUT fixture; this was simply our interpretation, but we agree that other options are feasible. We simply do not see the need to rotate the test points given that the FR2 MIMO OTA test is based on a 3D scan. We also do not see how compensating the channel model rotations avoids any ambiguities that we highlighted in R4-2006743 and above.
* As outlined earlier, our concerns with your proposal “Channel model rotations shall be specified in TR 38.827 and FR2 test points shall be rotated to compensate them on a per channel model basis.” is that we do not see how compensating channel model rotations will avoid the ambiguities we have highlighted. We agree to specify the channel model rotations in the TR though.
* Regarding your proposed WF:
	+ We do not see how the proposal “FR2 test points shall be rotated to compensate them on a per channel model basis” resolves any of the ambiguities we highlighted
	+ If you don’t agree with Option 1, can you comment why we cannot agree to Option 2 and the rotated probes (by 90deg in AZ) as we believe this is the best compromise in terms of blocking and leveraging a positioner coordinate system that is commonly used in OTA.
	+ If we leave everything as is, we believe that the very coarse grid of 36 test points and the highlighted ambiguities will yield significant differences. Those might be reduced with a much finer test point density, but we don’t think this is an option.
	+ We are also not sure how rotating the probes by 90deg is AZ alone is reducing ambiguities. However, when coupled with limiting the MIMO OTA implementation to Option 2 (P2) together with P4, this should yield no ambiguities and little to no blocking. We would like to hear what R&S’ concern is with Option 2 since Option 1 is considered invalid in their view.
* If we cannot agree on P2 and P4 to completely avoid the ambiguities, I hope that at a minimum we can agree to rotate the FR2 MIMO probes by 90deg in AZ (as outlined in Table 8 of our contribution) and define the revised probe layout in 38.827. This might reduce the probability of different system vendors implementing different options and might allow the majority of system vendors to adopt Option 4.

**Topic 1-3-3:*** As outlined in R4-1915075, different UL path implementations can yield differences in measured MIMO OTA performance when UBF is used. We therefore cannot agree to the use of UBF for NR FR2 MIMO OTA testing.
 |
| OPPO | Topic 1-3-2:* We have the same concern with some delegates that either option 1 or option 4 in R4-2006743 could not cover 3D test directions. The root cause is that the rotation axis of turntable perpendicular to the measurement probe plane, which makes coordinate system downgrade to 2D.
	+ Clarification needed by Keysight: “When you perform a 90deg roll of the device with Option 1, you will subsequently be able to sample the xz plane with AZ rotations between -180 and +180deg.” Here, how to “perform a 90deg roll”, along which axis?

Topic 1-3-3：* As Keysight mentioned above, different UL path implementations yield different MIMO OTA performance, and we believe it happens not only under the condition of UBF used. To minimize the measurement difference and measurement uncertainty, UL path implementation should be specified. Under this consensus, we can find solutions to make the UL signal captured stably with sufficient isolation between UL and DL.
 |
| Keysight | Response to OPPO:**Topic 1-3-2:*** Options 1 and 4 can certainly cover 3D test directions with the AZ and Roll stages, i.e., the 2-axis positioning system allows the UE to be rotated in 3D. It is not clear how this 2-axis positioning system downgrades testing to 2D.
* A clarification of the Roll and AZ stages are shown in a different visualization of the system for Option 1 below. Applying Roll would rotate the UE around the blue z axis.
*

**Topic 1-3-3:*** It is not clear why the near field coupling approach for the UL path cannot be leveraged for NR FR2 MIMO as this is done effectively for other FR2 measurement systems, e.g., UE RF.
 |
| Samsung | Issue 1-3-1: 3D-MPAC SNR analysis: ΔSNRmulti-probe range is [0, 7.8]dB without considering UE antenna pattern and TE beam weights. After considering UE antenna pattern with 8x2 array, the ΔSNRmulti-probe range is narrowed down to [0, 3.5]dB with a simple assumption on UE REFSENS at different probe direction. To get more accurate evaluation, it will be better if we can consider accurate UE REFSENS at different probe direction, and then involved with TE beam weights. We are open to further accurate evaluation but it will take time.Issue 1-3-2: UE orientations in 3D-MPAC system: we support the proposal to avoid ambiguity and to reduce blockage by standardized relative location among positioner, probe and UE. Among option 1/2/3, Option 1 has the least blockage. Option 4 is also similar. With respect to TE implementation flexibility, at least, the blockage should be minimized so that UE re-position during test can be avoided. Issue 1-3-3: FR2 Uplink path: we understand there are different approaches for uplink path as Keysight commented. We are fine with non-standardized uplink path. However, it is still meaningful to make sure no impact to MIMO OTA test due to uplink path approach. About UBF, as discussed in previous meetings last year, it is not preferred manner. |
| MediaTek | Topic 1-5-2:* Issue 1-3-1: 3D-MPAC SNR analysis

We think “**ΔSNRmulti-probe** = [0 to 7,8]” shall at least be defined in MIMO OTA WF, if we cannot define exact number in 2nd round in the end. Moreover, it’s still preferred if we can define exact number in 2nd round after TE vendor’s feedback. It would be beneficial for further discussion for potential requirement. |
| CAICT | Topic 1-1: Spatial correlation validation is the most time-consuming testing for channel model validation, tens of hours are usually required for one polarization, if vertical testing is sufficient, we suggest to limit the validation procedure to one polarization. In the WI phase, we can further check whether these two polarization validations are identical or show similar offset vs theoretical value. Regarding PSP validation for FR2, suggest to limit to one polarization, considering the measurement time and so complex procedure. During the pass/fail limit discussion stage we can further check if the reference antenna type has great impact on the validation results, and then make decision on whether detailed specifications are needed for reference antenna. Considering the QZ size is 20cm, suggest to add that PSP validation with radius of 10cm is FFS.Topic 1-3-2: Learned from LTE MIMO OTA, the throughput of UE is very sensitive with the UE orientations, which may increase more ambiguities when we discuss the FR2 UE performance from different labs in the next step. Therefore, it’s strongly encouraged to make conclusions on this topic to reduce the ambiguities.Topic 1-3-3: It’s clear that the intention of discussion UL path is to ensure stable uplink with minimum interference. Instead of standardizing the UL antenna position, we suggest to add the statement in the procedure that stable uplink connection shall be guaranteed with negligible interference. Comparison measurement results of UE performance under different uplink path implementation is encouraged.  |
| R&S | **Response to Keysight on Issue 1-3-2 (UE orientations in 3D-MPAC system):*** The figure above with the example for Test Point Direction #3 (theta=90º, phi=0º) clearly show how Option 1 is not respecting the DUT rotations according to the coordinate system in TR 38.827. You mention how a 90º roll gives you the ability to scan the xz plane but, following the example for Test Point Direction #3 (theta=90º, phi=0º), you would be actually testing theta=90º, phi=**90º** according to the positioner coordinatesand therefore references to thetha/phi polarizations (or vertical/horizontal) are lost.
* On the other hand, Option 2 on the same example do comply with DUT rotations with respect to the reference coordinate system. The issue shown in the second row for on Option 2 (positioner blocking the direction towards the probe array) is exactly the kind of case that can be solved by applying the re-positioning concept.
* The ambiguities shown in Keysight’s paper could also be solved by centering the probe array around theta = 0, so each test points physically correspond to the direction towards the probe array, and then follow the typical 2-axis positioner conventions in OTA and antenna testing. However, this option might impose very challenging limitations to the whole OTA test environment (chamber, probe placement, positioner…).
* It seems clear to us that we are looking at different issues: 1. R&S’ contribution raises the issue of the relative directions or arrival for each test point depending on the channel model; 2. Keysight’s contribution is focusing on how DUT is rotated to reach each of those test directions.
	1. On the first one, Keysight commented that they do not see the issue since the test is based on a 3D scan. If we do not compensate the test points rotation with the channel model rotation (as it was done during the simulation campaign), then we are eliminating a major component of the AoA/ZoA that differentiates each of the channel models and we would be focusing only on the angular spread. Feedback from the group whether this is acceptable or not would be appreciated.
	2. On the second issue, we are not ok to define a single positioner layout, but we agree that rotating the probes by 90º in AZ might help to solve some of the issues.
* Even though we think the DUT rotations are clear in current definition since all relations are fixed (coordinate system incl. theta and phi angles, DUT alignment and probe location), we can work during the WI phase to further clarify how the DUT rotations shall be implemented.

  |
| Keysight | **Response to R&S****Issue 1-3-2*** It is not clear to us where in 38.927 the UE rotations are defined. The coordinate system is defined in A.1 of 38.827 (specifically A.1-1), the DUT alignment to coordinate is defined in A.1 of 38.827 (specifically A.1-2). The TR, unlike other Technical Reports or Technical Specifications does not define positioner axes and coordinates, e.g., as in Clause B.2 of 38.508-1.
* It seems R&S might be confusing motor coordinates with theta, phi in the example given above. It states nowhere that the motor coordinate have to be aligned with the test point coordinates theta, phi. The examples clearly show that between Option 1 and 2 different motor rotations/coordinates are needed; however, in every case, the x axis of the UE coordinate system is aligned with the z axis of the channel model coordinate system which we believe a test point of (theta=90, phi=0) should do. Which motor coordinates I use to get there, depends on how the positioner coordinate system is picked and we are showing just two Options out of which Option 2 is the more traditional one. However, without having defined a positioner coordinate system, any assumption can be made and as we have shown, those will yield ambiguities.
* Re-positioning can certainly solve the positioner blocking effects. However, as shown, there is a way to avoid blocking.
* We agree that we are looking at different issues. We are addressing ambiguities and ways to prevent them while you are suggesting to compensate the channel model rotations but we don’t think they don’t address the ambiguity issue.
* Since you can agree to rotating the probes by 90deg in AZ, we will prepare the CR. We hope that we can add simple language to define how UE rotations are defined since we essentially aligned to adopt Proposal 3 but maybe need to work on the language a bit.
 |

## Summary on 2nd round

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
| R4-2006742 | *Agreeable* |
| R4-2008273 | *Agreeable* |
|  |  |
|  |  |

# Topic #2: Others (including Rel-15 TR38.810 maintenance)

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2006310 | CAICT | The latest FR1 MIMO OTA measurement results based on the agreed test system in TR38.827 is presented. Some observations on UE performance are also discussed. This selected approach is able to differentiate 4x4 MIMO OTA performance and more work for higher MCS is expected in the future. |
| R4-2007084 | OPPO | **Proposal 1:** UE movement with certain speed should be a typical dynamic testing scenario to evaluate the period of new beam re-obtaining and refining as one test case of dynamic testing.Technically, with the help of coordinate system conversion, the scenario of UE movement with certain speed could be re-structured in MPAC with UE rotation on the turn table, accompanied with downlink power change to simulate the BS-UE distance variation. Furthermore, the performance of new beam re-obtaining and refining should be evaluated under different UE movement speed. Obviously, these test scenarios can not be covered by current FR2 MIMO OTA 3D-MPAC static testing.**Observation 1:** UE movement based scenario can not be covered by current FR2 MIMO OTA 3D-MPAC static testing.**Proposal 2:** UE movement based scenario should be re-structured in MPAC with rotation and downlink power highly aligned to simulate movement speed. The scenario is recommended to be studied and implemented in a separate new SI. |
| R4-2007285 | Qualcomm Incorporated | **Proposal 1:** For MIMO OTA sensitivity requirements, RAN4 to agree the introduction of MMO-OTA T-put measurement during at least BEAM\_SELECT\_WAIT\_TIME based on agreed test conditions, e.g. Probe-layout, Channel model, etc. and to discuss performance metric to assess UE performances in WI phase. And during BEAM\_SELECT\_WAIT\_TIME, DL transmission power is constant and its level is FFS. |
| R4-2007563 | Qualcomm Incorporated | TP to TR38.827 on FR2 test procedure**Proposal: Include the following text proposal on FR2 test procedure in TR38.827.** |
| R4-2008014(TR38.810 CR) | Keysight Technologies | Beam correspondence – SRS configuration corrections in section 5.2.1.3.7Clarifed the ‘*usage*’ as ‘*beamManagement’* for the up to 8 SRS resources.Added the creation of an additional SRS resource set of type ‘*semi-persistent*’ and ‘*usage’* set to ‘*codebook’*.Clarified how the spatial relationship is set during semi-persistent SRS activation. |

## Open issues summary

### Sub-topic 2-1 FR1 MIMO OTA measurement results

* Discussion
	+ The latest FR1 MIMO OTA measurement results based on the agreed test system in TR38.827 is presented.
* Recommended WF
	+ TBA

### Sub-topic 2-2 FR2 dynamic testing

* Proposals
	+ **Proposal 1:** UE movement with certain speed should be a typical dynamic testing scenario to evaluate the period of new beam re-obtaining and refining as one test case of dynamic testing.
	+ **Proposal 2:** UE movement based scenario should be re-structured in MPAC with rotation and downlink power highly aligned to simulate movement speed. The scenario is recommended to be studied and implemented in a separate new SI.
	+ **Proposal 3:** For MIMO OTA sensitivity requirements, RAN4 to agree the introduction of MMO-OTA T-put measurement during at least BEAM\_SELECT\_WAIT\_TIME based on agreed test conditions, e.g. Probe-layout, Channel model, etc. and to discuss performance metric to assess UE performances in WI phase. And during BEAM\_SELECT\_WAIT\_TIME, DL transmission power is constant and its level is FFS.

 Related TP: R4-2007563

* Recommended WF
	+ TBA

### Sub-topic 2-3 Rel-15 TR38.810 maintanence in AI 4.13

* CR R4-2008014
	+ Beam correspondence – SRS configuration corrections in section 5.2.1.3.7.
* Recommended WF
	+ TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm | Sub topic 2-1: Sub topic 2-2:We agree that the dynamic test with the UE continue movement in Proposal 1&2 of R4-2007084 could be further studied in a new SI. Please note that proposal 3 which is from R4-2007285 is to reuse the current static testing setup and mechanism. The only difference is the T-put during the BEAM\_SELECT\_WAIT\_TIME will be measured with non-continue movement which is same as current static testing. Therefore, proposal 3 is clearly not the scenario of dynamic testing mentioned in R4-2007084. With this clarification, we propose the following WF on dynamic testing:* RAN4 to agree the introduction of MIMO-OTA T-put measurement during at least BEAM\_SELECT\_WAIT\_TIME based on agreed test conditions/setup and to discuss UE performance metric in WI phase
* RAN4 to recommend starting a new SI to further study other scenarios e.g. continue UE movement etc.

Sub topic 2-3: |
| Samsung | Sub topic 2-1: FR1 MIMO OTA measurement results* Thanks a lot for CAICT’s input. Measurement results show that 40MHz BW is doable for FR1 TDD 4x4
* A question on Figure 4 in the paper, are the test results obtained with 40MHz or 100MHz BW? We see both 40MHz and 100MHz in the figure.

Sub topic 2-2: FR2 dynamic testing* For proposal 3 (test MIMO OTA throughput during BEAM\_SELECT\_WAIT\_TIME), it is true that it can make use of the static MIMO OTA system, but there are still many technical issues, e.g.:
	+ BEAM\_SELECT\_WAIT\_TIME (T2) is meanwhile the dwell time for UE to be steady from vibration status after test point is changed from one to another. UE vibration during the dwell time may be quite different for different system and are also random. The MIMO OTA throughput test during T2 does not account for beam forming performance but also mechanical performance of test system which is beyond the scope.
	+ The test result repeatability is one of the most important aspects. The MIMO OTA throughput test during T2 can not guarantee test result repeatability.
	+ One more consideration is that UE speed is already a parameter for channel model, not sure if there is conflict to apply MIMO OTA channel model for a rotating UE in a dynamic test.
* Based on above considerations, we think dynamic test is not mature for Rel-16.

Sub topic 2-3: Rel-15 TR38.810 maintanence in AI 4.13* Thanks Keysight for identifying the SRS configuration issue for bit-0 UE beam correspondence test. We agree that the usage of SRS should be configured as ‘beamMnagement’. However, further study is needed about if addition SRS resource set should be configured. There may be different approaches for detailed configurations. On the other hand, further discussion with other WG is also expected. Given limited time for companies to look into this issue in RAN4, we hope that this issue could be postponed to Aug meeting.
 |
| CAICT | Sub topic 2-1: Response to Samsung: yes, in Fig. 4 we tested 40 MHz and 100MHz. Using MCS 19 with 100MHz is for checking the UE performance under “extreme condition”, to compare sensitivity performance with standardized MCS13 with 40MHz.Sub topic 2-2:We understand the intention of checking UE performance under beam switching condition. However, technically, many things are not clear. Based on the experience of LTE and FR1 MIMO OTA testing. The T2 (BEAM\_SELECT\_WAIT\_TIME) is not a constant window at each position, it could be 3 seconds or even several mins, and sometimes in this period reconnection may happen, for some UEs somehow they can not re-connect automatically, then the test engineer need to try fly-mode or reboot the phone for re-connection to continue the testing. Therefore, this is an unstable time period which is not repeatable. I put a throughput trend figure here for easy discussion.From another side, as shown in the figure above, it’s clear for everyone that agreed performance metric for “static testing” is similar to FR1, which is Sensitivity under stable connection with specific throughput rate. Even you use the same system with same channel model, when you want to check the UE status under unstable condition during rotation or beam selection/reconnection, this is obviously a NEW performance requirement for UE. Meanwhile, the main concern is that we are not clear which kind of new performance you want to define. Are you going to check one point during T2, or measure continuously during unstable T2 with [xx] ms interval time. Besides, I am not sure if T-put is a good metric for T2 time period, maybe time-based metric is better. So my suggestion for this topic is to identify the new performance metric of this time period first, and then discuss how to measure. Regarding the proposals for WF, I am fine to further discuss the wording, but I think if second bullet is agreeable for the group, then we don’t need the first one, because T2 is also main work for second bullet scope. |
| Huawei | Sub topic 2-2: FR2 dynamic testing1. Generally, demodulation test need to verify whether SNR requirement is satisfied under certain throughput. So during T3, the SNR and DL power need to be adjusted until BLER is reached. We would like to know, during T1 and T2, what is the test metric? What is exact test object recorded and how to judge on the UE with pass or fail. We don’t see any description in the paper.
2. Whether all 36 points should be tested during the dynamic test? How to handle with the points out of Refsens requirement, whether the UE is allowed to be disconnected considering the DL power is provided by the TE with the whole procedure?
3. By the way, we would like to know is there any restriction on the UE rotation velocity during T1 and T2, and how to ensure on this restriction? Is there any specific requirement corresponding to different rotation model?

We don’t see any analysis on the above issues. It is not clear how UE proceed with such test, what metric the UE targets to and how to judge on the test results. Honestly saying, there is not enough time for dynamic test in Rel-16. Propose to exclude this issue in Rel-16. Whether a Rel-17 SI depends on RAN decision. |
| Qualcomm | Response to Samsung’s comments on Sub topic 2-2:Please find our response below:* For the first bullet, the issue should be due to the inconsistency of positioner in different test houses, e.g. positioner in two test houses might need different time durations to be stabilized from one test direction to another. Based on our survey, the time duration for positioner from one to another direction should be order of millisecond. Compared with 3sec dwell time, the impact of this millisecond difference can be ignored. In case, the impact can’t not be ignored, then this should be included in MU budget. We encourage TE vendors to provide more input on the positioner performance, e.g, how long does it take to be stabilized etc.
* For the second bullet, the repeatability issue should also be due to the inconsistency of positioner. Thereofre, it can be solved as the response in the first bullet. Additionally, there should not be repeatability issue in the same test house.
* For the third bullet, there is no any discrepancy with channel model. It follows the same principle as current static testing which means the UE speed is only considered in the channel model and it is emulated by channel emulator. The measurement in T2 keeps the same direction as T3 which means all the measurement would be from a static/fixed test direction.
* Please note that the requirements will be discussed in Rel-17 MIMO OTA WI. And the setups, channel modle and test procdure are reused from the current static testing of Rel-16 SI.

Response to CAICT’s comments on Sub topic 2-2:Please find our response below:* BEAM\_SELECT\_WAIT\_TIME is defined in RAN5 test spec which is 3sec for UE to refine the beam in RF test cases. We can take [3sec] as the example to illustrate the how to measure the T-put in T2. During the T2 period, DL power is fixed, and then the average MIMO T-put which is defined in 5.1.1 of TR38.827 is measured continuously in each T2. Therefore, after all 36 test directions are tested, we can obtain at least 35 average T-put for T2 period, e.g. 30%, 40%, 45% of maximum T-put etc. With the 35 average T-put measurement results, we can draw the below CDF curve which is similar as current static potential performance metric options. The only difference is the x-axis is T-put but not sensitivity. With this curve, we can define the performance metric for T2. Actually, we are open to other options on performance metric. Companies are welcome to provide input on this in WI phase.

* Regarding the disconnection issues, if we assume the maximum DL power is used for T2 measurement, we believe disconnect should not happen frequently. Moreover, as shown above figure, with a proper X% value when defining performance metric, the average T-put with disconnection in T2 can be skipped. Therefore, we can solve the disconnection issue with a proper X value when defining the performance metric for T2.
* We would clarify the proposed requirement in T2 is a separate additional requirement with T3 which is current static testing. And it will have NO impact on the current static performance metric.
* Regarding the WF, the first bullet is to reuse the current setup to do the additional measurement and further study the performance metric in WI phase. The average T-put mentioned in above figure can be as starting point for performance metric in T2. The second bullet is to study a new setup and methodology which is different from the current one for more real dynamic scenario, e.g. UE continue movement and beam changing from gNB.

Response to Huawei’s comments on on Sub topic 2-2:* Regarding 1), the response can refer to the first bullet of response to CAICT. And we would clarify that the average MIMO T-put can be calculated by the equation defined in 5.1.1 of TR38.827. At T2 period, the measurement is the same as static testing with a certain DL power. But in this case, there is no target value e.g. [70%] or [90%] of maximum T-put which is defined in static testing.
* Regarding 2), the response can refer to the second bullet of response to CAICT.
* Regarding 3), Could Huawei clarify what does “restriction on the UE rotation velocity” mean? We think there is no restriction on UE rotation. Based on our survey, the time duration for positioner from one to another direction should be order of millisecond. Compared with 3sec dwell time, the impact of this millisecond difference can be ignored. TE vendors can provide more views on this.
* Please note that the requirements will be discussed in Rel-17 MIMO OTA WI. And the setups, channel modle and test procdure are reused from the current static testing of Rel-16 SI. Therefore, this would not be a Rel-16 requirment. And the only open issue for this is how to define the performance meric. We can use the option shown above figure as the starting point for performance metric discussion in WI phase.

Sub topic 2-3: Rel-15 TR38.810 maintenance in AI 4.13* In general, we are fine with the Keysight’s CR. We noticed there is a similar CR submitted to RAN5. RAN4 CR should align with RAN5’s conclusion.
 |

### CRs/TPs comments collection

*NR MIMO OTA is a close-to-finalize SI, suggest to focus on finalizing the text proposals for TR.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| R4-2007563 | Samsung: “Keep downlink signal power from step 2” is not feasible. As to whether changing downlink power to maximum downlink power, it may depends on implementation or algorithm of different test system. Comments from TE vendors are expected. At least it may be not necessary to be captured in the test procedure in TR of SI. |
| CAICT: before simply adding additional test procedure, it’s better to align on the new performance metric for T2 first.  |
| R4-2008014 | Samsung: As commented above in 1st round, it is beneficial to collect view in this meeting, but prefer to postpone further discussion in Aug meeting. |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic 2-1** **FR1 MIMO OTA measurement results** | *Tentative agreements:* *Recommendations for 2nd round:** None
 |
| **Sub-topic 2-2 FR2 dynamic testing** | *Tentative agreements:* *Recommendations for 2nd round:** Further discuss suitable performance metric for T2 time period. Identify a proper way to proceed on this topic. Further check if GTW meeting session is needed.
 |
| **Sub-topic 2-3 Rel-15 TR38.810 maintenance in AI 4.13** | *Tentative agreements:* *Recommendations for 2nd round:** Further discuss on this topic.
 |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| R4-2007563 | *to be revised* |
|  |  |

## Discussion on 2nd round

### Sub-topic 2-2 FR2 dynamic testing

*Tentative agreements:*

*Recommendations for 2nd round:*

* Further discuss suitable performance metric for T2 time period. Identify a proper way to proceed on this topic. Further check if GTW meeting session is needed.

### Sub-topic 2-3 Rel-15 TR38.810 maintanence in AI 4.13

*Tentative agreements:*

*Recommendations for 2nd round:*

* Further discuss on this topic.

|  |  |
| --- | --- |
| **Company** | **Comments for 2nd round** |
| Qualcomm | 2.5.1 Sub-topic 2-2 FR2 dynamic testing:Based on 1st round comments and recommendations for 2nd round, we would clarify the proposal as below:* The proposed measurement window is defined as below i.e., T2:
	+ The starting point of measurement window begins at least after UE rotation update.
	+ The ending point of measurement window is before the starting point of current MIMO OTA measurements.
	+ The measurement window length is TBD.
	+ TE can exactly control to start the measurements once UE rotation update is finished.
* DL power configuration for measurement window:
	+ Set the DL power at the maximum power level
* Performance metric:
	+ Option 1: T-put at X% CDF of average T-put should be larger than Y% maximum MIMO T-put with fixed RMC.
	+ Other options are not precluded and can be further discuss in the WI phase
 |
| R&S | **Sub-topic 2-2 (FR2 dynamic testing)**: * Measurements limited to T2 (i.e. after movement is finished between previous test point to the next) ensures the MIMO OTA channel model is not affected since the measurement would be performed without any DUT movement.
* On the other hand, it is unclear how stable is the connection during T2 to allow a throughput measurement or if it could be impacted by call drops. Thus, additional test conditions or test steps should be added, like increasing to max DL power before T1 (i.e. movement from previous point to the next), to improve the stability of the test.
* Finally, the default value for BEAM\_SELECT\_WAIT\_TIME is 3sec according to TS 38.521-2, but it can be reduced for a particular DUT in order to reduce test time. This shouldn’t be allowed for MIMO OTA so throughput measurements during T2 are always performed under same conditions for all DUTs.
 |
| CAICT | **Sub-topic 2-2 (FR2 dynamic testing)**: Maximum power level of the system is not often used for actual UE testing, this is only for some very bad-performance UE which is hard to reach max throughput under specific orientations. It’s harmful for the MIMO OTA system with many high-power amplifiers to work under extreme power condition. Regarding the performance metric, before discussing the CDF or [xx]% of maximum throughput, it’s better to make it clear whether the new metric of “averaged T-put vs Time” is meaningful to specify the “Beam Switching/Refinement stage” performance. Aligned performance metric from the group is needed first for this new test case. If this is identified as the valuable additional MIMO OTA requirement, then we could further study the feasibility of testing. Besides, considering these are different testing with totally different intention, the test procedure shall be a separated one, not merged into traditional static testing procedure.  |

## Summary on 2nd round

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
|  |  |
| R4-2008866 | *No consensus on this topic in Rel-16* *To be noted* |

## Refrenece

1. R4-2005556, WF on FR2 MIMO OTA, CAICT, Keysight, Spirent, 3GPP TSG-RAN WG4 Meeting #94-e-bis, April 2020