**3GPP TSG-RAN WG4 Meeting # 97-e R4-20XXXXX**

**Electronic Meeting, 2 – 13 Nov., 2020**

**Agenda item:** 12.1.1

**Source:** Moderator (CAICT)

**Title:** Email discussion summary for [97e][330] NR\_MIMO\_OTA

**Document for:** Information

# Introduction

In the last RAN plenary meeting, NR MIMO OTA open issues were captured in the WI status report [1]:

*Remaining Open issues：*

*• Down-selecting of FR2 channel models and RMC*

*• Pass/Fail criteria for channel model validation*

*• Potential optimization of test methods for FR1 and FR2*

*• How to process the measurement data for FR2*

*• Lab alignment for performance requirements definition*

*• Specify the FR1 MIMO OTA requirements*

*• Specify the FR2 MIMO OTA requirements*

AI 12.1 NR MIMO OTA WI and 7.19.7 TR38.827 maintenance are included in this email discussion.

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

• 1st round: agree TPs and CRs, discuss the open issues for NR MIMO OTA.

• 2nd round: make decision on open issues for NR MIMO OTA based on the decisions of 1st round.

# Topic #1: General and Testing methodologies

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2016217 | vivo, CAICT | “LS on FR1 MIMO OTA”**Observation 1: Industry fragmentation of LTE MIMO OTA test methods are shown in different SDOs.****Proposal 1: Send a LS on FR1 MIMO OTA to the SDOs outside of 3GPP. Aligned test methodology to minimize the industry fragmentation on FR1 MIMO OTA is encouraged.** |
| R4-2014723 | Samsung | “Discussion on FR1 and FR2 MIMO OTA”**Observation 4: 64QAM is not feasible for FR2 high bands due to limited SNR.****Observation 4: 64QAM is not feasible for FR2 low bands since 95%TP is difficult to be achieved.****Proposal 5: For FR2 NR MIMO OTA, 16QAM is adopted as downlink modulation for all FR2 bands.** |
| R4-2016219 | vivo, CAICT | “Discussions on FR2 MIMO OTA requirements”**Proposal 4: Select 16 QAM as the only RMC for FR2 MIMO OTA requirements.** |
| R4-2016235 | Qualcomm Incorporated | “Views on for FR2 MIMO OTA”**Observation 1: The achievable SNR in 3D-MPAC is ~15.3dB for n260. There is still a gap between achievable and required SNR for 64QAM in CDL channel.****Observation 2: To make sure the selected RMC is testable in 3D-MAPC, selecting 16QAM is reasonable if no further update on achievable SNR from companies.****Proposal 1: RAN4 to select 16QAM RMC to define the FR2 MIMO OTA requirements at this stage. Further check the feasibility of 64QAM RMC based on the technical input from companies.****Proposal 2: To increase the test coverage and fully utilize the capabilities of 3D-MPAC, RAN4 to keep both InO CDL-A and UMi CDL-C for FR2 MIMO OTA testing.** |
| R4-2016589 | Huawei, HiSilicon | “Discussion on open issues of NR MIMO OTA WI”**Proposal 3: use 16QAM with 100MHz bandwidth as FR2 MIMO OTA RMC for n257/n258/n261. For n260, consider QPSK, or reduce the bandwidth for 16QAM (e.g. 16QAM with 25 or 20MHz bandwidth).** |
| R4-2015368 | HUAWEI, HiSilicon | “Discussion on MIMO OTA test methodologies”**Proposal 1: We prefer to keep UMi CDL-C as final requirement in NR FR2 MIMO OTA.** |
| R4-2016208 | Keysight Technologies | “On FR2 MIMO OTA channel model down selection”**Observation 1: Given the novelty of FR2 MIMO, there is benefit to keep both InO CDL-A and UMi CDL-C, typical scenarios for FR2 deployment****Observation 2: CDL-A InO model incudes just one dominant spatial cluster and thus does not provide much additional test coverage compared to the single AoA demodulation conformance testing.****Observation 3: CDL-C UMi model provides more degrees of freedom for the DUT to steer its beam direction and allows for better differentiation in performance between different DUTs.****Proposal 1: If just a single channel model is required for FR2 MIMO OTA testing, select the CDL-C UMi channel model.** |
| R4-2016209 | Keysight Technologies | “On FR1 4x4 vs. 2x2 channel models”**Proposal: It is proposed to adopt CDL-C UMa model for 4x4 testing and CDL-A UMi model for 2x2 testing.** |
| R4-2016210 | Keysight Technologies | “On Probe Configurations and Channel model vs. OTA test system coordinate systems for FR2 MIMO OTA”**Observation 1: The new proposed probe configuration has the probes aligned towards the z axis with probe #1 along the z direction.****Observation 2: The QoQZ validation can readily be performed with probe #1 as the fully documented UE RF and RRM 2AoA QoQZ validation procedures are also assuming the measurement probe in the z direction.****Observation 3: The blocking with this probe configuration is rather limited.****Proposal 1: Adopt the revised probe configuration in Table 1 for NR FR2 MIMO OTA****Proposal 2: Define channel model coordinate axes xCM, yCM, and zCM which correspond to the OTA test system coordinate axes z, y, and -x, respectively** |
| R4-2015353 | OPPO | “The rules for 3D-MPAC system implementation”**Proposal:** **Two rules should be followed when implementing the 3D-MPAC system:****Rule One: Rotate the probes towards the z axis direction, to constraint the probe location in relation to the 2-axis turntable.****Rule Two: Keep the Reference Direction Indicator along the longitude line on DUT spherical surface and pointing to upper hemisphere, to constraint the probe placement in relation to the DUT orientation.** |
| R4-2015258 | Xiaomi | “on UE orientation clarification”**Proposal 1: Apply figure 1 as probe configuration to avoid blocking effect.****Observation 1: The probe position and test point position defined by theta and phi are based on specific co-ordination system.****Observation 2: The test point positions need to be aligned when the cluster of probe position is changed.****Proposal 2: To rotate the co-ordination as X degree to define new test points according to the rotation of probe configuration.** |
| R4-2016561 | CAICT, Keysight, vivo | “FR1 MIMO OTA channel model validation results”**Observation 1: Some of the theoretical reference values of the channel model verification after considering the filtering effect of the base station are currently absent.****Proposal 1: Theoretical values of channel model validation with base station antenna filtering effect shall be provided as reference.****Observation 2: The measured PDP of CDL-A UMi channel models matches well with the simulated reference.** **Observation 3: The dynamic range of different clusters in PDP measurement results exceeds 40 dB due to the effect of BS pattern filtering. It could be difficult to measure the “weak” clusters accurately.****Proposal 2: Focus on the high power clusters (e.g. dynamic range within 40dB) in the follow-up WI phase for defining the channel model validation limits. Alternatively, consider relaxing the limits of “weak” clusters (e.g. below -40dB).****Observation 4: The measured spatial correlation of FR1 CDL-A UMi channel model matches well with the theoretical reference.** |
| R4-2014536 | Spirent Communications | “Channel Model Assumptions”**Proposal 1. Agree on ideal curves for FR2 channel models, for PDP, Doppler Temporal Correlation.****Proposal 2. Agree on additional values for FR2: PSP, V/H ratio, Cross Correlation Matrix.****Proposal 3. Work out limits for each FR2 validation parameter.** |
| R4-2016539 | Huawei, HiSilicon | “Simulation assumptions for NR FR2 MIMO OTA”**Proposal 2: The number of clusters shall be clearly regulated in different scenarios. We prefer Option 3.** |
| R4-2016218 | vivo, CAICT | **TP to TS 38.151 v0.0.1 on general part** |
| R4-2016221 | vivo, CAICT, Spirent | **TP to TS 38.151 v0.0.1 on FR1 Channel model and RMC** |
| R4-2016222 | vivo, CAICT | **TP to TS 38.151 v0.0.1 on FR1 test system for requirements** |
| R4-2016216(reserved) | vivo | New version TS |
| R4-2016220(reserved) | vivo | “Channel model simulation for FR1 performance requirement” |
| R4-2014688Late contribution | BUPT | Effect of White Box Approach on Simple-Sectored Multi-Probe Anechoic Chamber Design**Proposal 1: As for multiple adaptive sub-arrays that operate in spatial multiplexing mode, the spatial correlation error between sub-arrays as the metric for DUT.****Proposal 2: Applying the white box testing approach for NR FR2 conformance testing. It requires the declaration by the manufacturer about the detailed locations of the antenna panels within the DUT.****Proposal 3: To ensure accurate emulation of spatial correlation between multiple active sub-arrays on the terminal, a much more expensive setup configuration is expected, compared to single active sub-array terminal case.** |

## Open issues summary

### Sub-topic 1-1 General

**Issue 1-1-1: LS on FR1 MIMO OTA**

* Proposals
	+ Proposal 1: Send a LS on FR1 MIMO OTA to the SDOs outside of 3GPP. Aligned test methodology to minimize the industry fragmentation on FR1 MIMO OTA is encouraged.
* Recommended WF
	+ TBA

### Sub-topic 1-2 Testing parameters for Performance

**Issue 1-2-1: FR1 4x4 vs. 2x2 channel models**

* Proposals
	+ Proposal 1: Adopt CDL-C UMa model for 4x4 testing and CDL-A UMi model for 2x2 testing.
* Recommended WF
	+ Make decision on whether change of channel models mapping is needed.

**Issue 1-2-2: Down-selecting of FR2 RMC for performance requirement**

* Proposals
	+ Proposal 1:
		- Option 1: Adopt 16QAM RMC as the only RMC for all FR2 bands (Samsung, vivo, CAICT, QC).
		- Option 2: Use 16QAM with 100MHz bandwidth as FR2 MIMO OTA RMC for n257/n258/n261. For n260, consider QPSK, or reduce the bandwidth for 16QAM (e.g. 16QAM with 25 or 20MHz bandwidth) (HW).
	+ Proposal 2: Further check the feasibility of 64QAM RMC based on the technical input from companies.
* Recommended WF
	+ Make decision on FR2 RMC down selection this meeting.

**Issue 1-2-3: Down-selecting of FR2 channel model for performance requirement**

* Proposals
	+ Option 1: keep UMi CDL-C as final requirement in NR FR2 MIMO OTA.
	+ Option 2: keep both InO CDL-A and UMi CDL-C for FR2 MIMO OTA testing.
* Recommended WF
	+ TBA

### Sub-topic 1-3 Optimization of test methodologies

**Issue 1-3-1: System implementation of 3D-MPAC**

* Proposals
	+ Proposal 1a: Adopt the revised probe configuration below (Table 1) for NR FR2 MIMO OTA

Table 1: Proposed Probe Locations

|  |  |  |
| --- | --- | --- |
| Probe Number | Theta/ZoA [deg] | Phi/AoA [deg] |
| 1 | 0.0 | 0.0 |
| 2 | 11.2 | 116.7 |
| 3 | 20.6 | -104.3 |
| 4 | 20.6 | 104.3 |
| 5 | 20.6 | 75.7 |
| 6 | 30.0 | 90.0 |

* + Proposal 1b: Define channel model coordinate axes xCM, yCM, and zCM which correspond to the OTA test system coordinate axes z, y, and -x, respectively.
	+ Proposal 2a: Apply figure below (figure 1) as probe configuration to avoid blocking effect.
	+ Proposal 2b: To rotate the co-ordination as X degree to define new test points according to the rotation of probe configuration.



Figure 1 Illustration of the probe position

* + Proposal 3: Two rules should be followed when implementing the 3D-MPAC system:
		- Rule One: Rotate the probes towards the z axis direction, to constraint the probe location in relation to the 2-axis turntable.
		- Rule Two: Keep the Reference Direction Indicator along the longitude line on DUT spherical surface and pointing to upper hemisphere, to constraint the probe placement in relation to the DUT orientation.
* Recommended WF
	+ Make decision on system implementation of 3D-MPAC this meeting.

**Issue 1-3-2: White Box Approach on SS-MPAC**

* Proposals
	+ Proposal 1: As for multiple adaptive sub-arrays that operate in spatial multiplexing mode, the spatial correlation error between sub-arrays as the metric for DUT.
	+ Proposal 2: Applying the white box testing approach for NR FR2 conformance testing. It requires the declaration by the manufacturer about the detailed locations of the antenna panels within the DUT.
	+ Proposal 3: To ensure accurate emulation of spatial correlation between multiple active sub-arrays on the terminal, a much more expensive setup configuration is expected, compared to single active sub-array terminal case.
* Recommended WF
	+ TBA

### Sub-topic 1-4 channel model validation

**Issue 1-4-1: Channel model validation procedure**

* Proposals
	+ Proposal 1: Theoretical values of channel model validation with base station antenna filtering effect shall be provided as reference.
	+ Proposal 2: Focus on the high-power clusters (e.g. dynamic range within 40dB) in the follow-up WI phase for defining the channel model validation limits. Alternatively, consider relaxing the limits of “weak” clusters (e.g. below -40dB).
	+ Proposal 3: For FR2 MIMO OTA, choose 3 or 4 strongest clusters, i.e. 3 for CDL-A as cluster #2, #3 ,#4, 4 for CDL-C as cluster #6, #7, #8 ,#2, for each channel model that the BS strongest beam toward to.
* Recommended WF
	+ Companies are encouraged to share their views on pass/fail criteria of channel model validation.

**Issue 1-4-2: Channel model validation limits for FR2 MIMO OTA**

* Proposals
	+ Proposal 1. Agree on ideal curves for FR2 channel models, for PDP, Doppler Temporal Correlation.
	+ Proposal 2. Agree on additional values for FR2: PSP, V/H ratio, Cross Correlation Matrix.
	+ Proposal 3. Work out limits for each FR2 validation parameter.
* Recommended WF
	+ TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Keysight | **Issue 1-2-3: Down-selecting of FR2 channel model for performance requirement*** Given the novelty of FR2 MIMO, keeping both InO CDL-A and UMi CDL-C would be preferred and if absolutely needed, select a single channel model at a later time. If a channel model needs to be selected now, select CDL-C UMi

**Issue 1-3-1: System implementation of 3D-MPAC** * Regarding Proposal 2a: The proposed probe location would rotate probes with the highest probe weights a bit too away far from the z axis
* Regarding Proposal 2b: this proposal is not very clear
* Regarding Proposal 3: those two rules do not allow the removal of ambiguities as too many degrees of freedom are still allowed. For instance, either of the following two proposals would be allowed as they both follow Rules One and Two:

Clearly, both probe configurations would be vastly different which should be avoided given the differences in results these approaches could yield. Additionally, the approach per Proposal 1a would not be allowed since Rule Two would be violated (RDI is pointing towards the lower hemisphere). **Issue 1-3-2: White Box Approach on SS-MPAC*** The intention of proposal 1 is not clear without studying some of the references in detail separately. It was previously agreed (in the SI) to use the PSP metric to determine the probe configurations; a more thorough explanation in the contribution would have been preferred why spatial correlation error is the better approach. We agree that spatial correlation could be one relevant metric for MIMO over the multiple simultaneously active arrays. But a more thorough investigation for comparison between PSP, spatial correlation and correlation between beamforming arrays would be required before choosing the metric. The correlation between two or multiple beamforming arrays is not directly defined by spatial correlation, and therefore it may not be relevant to take the spatial correlation as the metric. Other metrics, such as PSP may be more suitable also because spatial correlation is challenging to achieve as demonstrated in the paper.
* Changing to a white box testing approach would require frequent re-positioning of the device during the testing of 36 test points as different antenna panels could be activated depending on test point/DL direction.
* Increasing the test setup complexity to the 38 probes (as mentioned in Observation 6) would be cost prohibitive. A study of alternate metrics as well as acceptable spatial correlation limits would be required. Feedback from industry is requested whether and when multiple simultaneous panels should be considered.

**Issue 1-4-1: Channel model validation procedure*** Regarding P1: we agree to provide those theoretical values
* Regarding P2: we agree that 40dB might be a good starting point for the dynamic range
* Regarding P3: All clusters have been considered in previous PSP simulations. We believe all clusters and rays should be included in the channel model implementation as described in 38.827. If number of clusters needs to be limited for some reason, it should be based on some power criteria, for example 40 dB

**Issue 1-4-2: Channel model validation limits for FR2 MIMO OTA*** We would like Spirent to clarify what the Cross Correlation Matrix metric (from R4-2014536) is as no such parameter was defined in 38.827.

….Others: |
| Xiaomi | **Issue 1-1-1: LS on FR1 MIMO OTA:**We agree with the intension of the LS. However, we might need some clarification of the alignment procedure as how to handle the difference between two SDOs.**Issue 1-2-1: FR1 4x4 vs. 2x2 channel models:** Agree with proposal 1. Consider the deployment scenario, the UMa will need large antenna gain while UMi will need relatively smaller gain.**Issue 1-2-3: Down-selecting of FR2 channel model for performance requirement:** We also want to check the probability to keep both, if not, then option 1 is preferred.**Issue 1-3-1: System implementation of 3D-MPAC**1, Firstly some reply to Keysight. As captured in TS 38.521-2 the QoQZ validation, only one antenna is used for QoQZ validation. We might need some more discussion to see whether only one probe is enough for the validation procedure? If no, then the “one probe towards the Z-axis” is not a necessary requirement for the system.If yes, then we think the validation can be performed with a single antenna separately so that there will be no limit to the probe configuration because of QoQZ.Hence as the limitation on “one axis towards directly to z-aixs” is not necessary, then we can have the freedom to locate the probes to avoid the blocking issue.2, Some clarification about proposal 2b as: Currently the 36 points are defined in a specific X-Y-Z co-ordination while the 6 test probes are specifically towards the y-axis. If we rotate the probes towards the Z-axis, then the 36 points should also be rotated accordingly. Further, if we move the probes upper, it can be assumed as a rotation in the Z-Y plane with certain degree and hence a second rotation is needed.3, For OPPO’s rules, we think we are quite aligned. Our proposal is one of the configuration that fulfils the rules. But as Keysight points out, there might still be ambiguity by applying these two rules, hence we think to capture the rules with additional example might be a WF. |
| Samsung | Sub topic 1-1 General: **Issue 1-1-1: LS on FR1 MIMO OTA**We support this LS. At the early stage of NR MIMO OTA SI, there was strong desire to avoid standard fragmentations between SDOs. Now 3GPP has finished the study phase and is leading the NR MIMO OTA standardization. It is helpful to share with other SDOs outside of 3GPP and come up with aligned MIMO OTA test methods etc. for the entire industry.Sub-topic 1-2 Testing parameters for Performance:**Issue 1-2-2: Down-selecting of FR2 RMC for performance requirement**We support option 1 of proposal 1, i.e. 16QAM as the only RMC for all FR2 bands as long as no critical issue could be identified. About the concern on limited SNR on FR2 high bands in option 2, besides falling back to QPSK, other methods may also be considered, e.g., only 70%TP or lower outage point for performance requirement and/or some exception points allowed for FR2 high bands, etc.**Issue 1-2-3: Down-selecting of FR2 channel model for performance requirement**Option 1 is preferred so that only one channel model will be adopted for performance requirement as agreed in the WF of last meeting in R4-2012707, i.e. “the goal is to select one for final requirement”. We are fine to keep both for study but finally select only one.Sub-topic 1-3 Optimization of test methodologies:**Issue 1-3-1: System implementation of 3D-MPAC**About probe location, proposal 1~3 are generally aligned. Proposal 1 seems a good trade off which enables 3D scan and also minimizes blocking effect. If the X=75deg then proposal 2 is the same as proposal 1.A question to OPPO’s rules. Rule one is already addressed by the agreement of last meeting. About rule 2, we understand the ambiguity there, but if DUT position is aligned (38.827 says “Position the DUT in the default P0 alignment option (Orientation 1)”), then there may be no ambiguity after implementing the new probe location towards z-axis?**Issue 1-3-2: White Box Approach on SS-MPAC**It was agreed in R4-1904160 that black box approach is adopted for both FR1 and FR2. If further study is needed on SS-MPAC, we prefer to only consider black box approach. |
| vivo | Sub topic 1-1 General: **Issue 1-1-1: LS on FR1 MIMO OTA**Feedback to Xiaomi, for LTE, the difference exists and there is no chance to revisit LTE MIMO OTA in each SDO. If you mean NR, for NR, only 3GPP develops NR MIMO OTA test method at this stage. Sub topic 1-2: **Issue 1-2-1: FR1 4x4 vs. 2x2 channel models**Agree that the initial selection of these two channel models was not based on evaluation of the suitability for mapping different test scenario. The rough idea at that time is that UE would most likely operate with 2x2 in Urban Macro and 4x4 in Urban Micro, that’s why we make the FR1 scenarios mapping at an early time:7 Channel Models7.1 GeneralThe different channel models are defined to create corresponding complex multipath radio propagation conditions for FR1 and FR2. The following scenarios are selected for NR MIMO OTA:FR1 scenarios:* For 2x2 MIMO: Urban Macro
* For 4x4 MIMO: Urban Micro

Before making the decision of switching UMa for 4x4 and UMi for 2x2, we would like to see more analysis on the channel models vs SNR to identify proper test scenario. We are doing some simulation analysis and hope to share the results during 2nd round.In addition, to keep the previous agreements of FR1 scenarios of 2x2 with UMa and 4x4 with UMi, if CDL-A UMi is not suitable for 4x4 testing, we would like to propose to replace CDL-A UMi by CDL-C UMi for 4x4. Simulation analysis or measurement results for CDL-C UMi channel model is encouraged.**Issue 1-2-2: Down-selecting of FR2 RMC for performance requirement**Seems it is the group common understanding that 16QAM RMC shall be adopted as the only RMC for FR2 MIMO OTA. Making decision on RMC for FR2 is important to reduce the simulation or measurement workload for next steps.Some papers for FR2 SNR range have been discussed, frankly speaking, I have to say these papers are all not correct, because the internal/physical path loss of Channel emulator are not included. The typical internal loss of CE is 18dB (could be 23dB, if High Gain Mode is not active): Although digital gain can be provided by CE, the internal path loss is still always over 3dB, considering the output gain should not be set as maximum due to digital signal distortions and other factors. This means the actual SNR dynamic range of FR2 MIMO OTA system is even worse than everyone’s expectation.Therefore, there is no doubt that 16QAM should be selected for FR2 MIMO OTA.Regarding Option 2, the minimum bandwidth of NR FR2 is 50MHz, not clear where does the “25 or 20MHz bandwidth” for n260 come from? Share similar view with Samsung that different KPI can be defined for FR2 high bands.**Issue 1-2-3: Down-selecting of FR2 channel model for performance requirement**Support keeping UMi CDL-C as final requirement for NR FR2 MIMO OTA.If companies have strong interests to study 2 channel models at this stage, UMi CDL-C should be clearly stated as 1st priority, to focus the group’s efforts on next-steps simulation or measurements.Anyway, as stated in the agreed WF “*the goal is to select one for final requirement*”, we believe FR2 requirement based on one channel model is the target in the end, Sub topic 1-3:**Issue 1-3-1: System implementation of 3D-MPAC**Based on our calculation, Proposal 1a are exactly the new z-direction probes rotated from original y-direction positions. We are OK with Proposal 1a. Regarding Proposal 1b, we understand that rotating the centre of gravity of channel models may lead to changes of many channel model parameters for each cluster. However, if the two separate coordinate systems exist, then it would be hard to identify UE throughput performance issue related to cluster characteristics, based on the results measured in the chamber with a different coordinate system, for UE design or R&D purpose. In addition, we are confused about the channel model rotation procedure in the proposed two different coordinate systems.**Issue 1-3-2: White Box Approach on SS-MPAC**No need to re-open the black-box or white-box discussion for NR MIMO OTA. Sub topic 1-4:**Issue 1-4-1: Channel model validation procedure**We support P1. As stated in clause 7.3 of TR 38.827, the propagation environment generated in the test zone is channel model defined in section 7.2 with base station antenna filtering effect. It is reasonable to validate the channel model implementation (all the aspects including PDP, Doppler, Spatial correlation, Cro-pol and Center Power) of FR2 MIMO OTA system with BS antenna filtering effect. For P2, as indicated by many papers during the system layout discussion, many very weak clusters after BS filtering and meaningless and even not be generated by CE in the chamber. Therefore, we agree the channel model validation should focus on the high-power clusters. However, how to define the threshold, e.g. 30dB, 35dB or 40dB, should be discussed, more inputs are needed.For P3, not so clear where does this proposal come from. we believe this proposal is for FR2 simulation assumption but not for channel model validation procedure, which should be moved to issue 2-4-2 (Simulation assumption for FR2 performance evaluation). Response to vivo:Regarding P3, according to the offline communication with Hisilicon, the intent of this proposal is not only applicable to FR2 simulation assumption, but also applicable to actual FR2 MIMO OTA measurement, so they recommend repeating this proposal in issue 1-4-1 and issue 2-4-2.**Issue 1-4-2: Channel model validation limits for FR2 MIMO OTA**We are fine with the P1 and P3. For P2, Cross Correlation Matrix should not be considered for FR1. Considering even ideal characteristic of channel model from16 probes system has large offset with theoretical values (RMS error >0.2), it would be helpful for readers outside of 3GPP to see both ideal curve and simulation curve of 10 probes model. Similar to the figure below for LTE MIMO OTA (the 8-probe curve maybe more important to be a reference in this figure):Therefore, ideal curve of 16 probes Model is encouraged and should also be added in the spec.Response to vivo:Do you mean ideal curve of 6 probe for FR2 channel model here? Because 16 probes are for FR1 and only curves for FR2 channel model are presented in this issue. But we support that for FR1 MIMO OTA, ideal curves of 16 probes could be an important reference due to the suboptimal system implementation. |
| Huawei | **Issue 1-1-1: LS on FR1 MIMO OTA**In general we support the idea of this LS, it is a good to harmonize the OTA methodology in different SDO, e.g. CTIA, CCSA and 3GPP. **Issue 1-2-1: FR1 4x4 vs. 2x2 channel models**Thank keysight for providing these comprehensive simulation and testing results, we support proposal 1.**Issue 1-2-2: Down-selecting of FR2 RMC for performance requirement**We proposed option2 in our paper. According to our calculation, we expect the feasible SNR **SNR3D-MPAC ~ 11.8+[0, 3.5]dB** for n260 of 100MHz bandwidth. However the demodulation requirement of “R.PDSCH.5-2.2 TDD” in Table A.3.2.2.5-2 of TS 38.101-4 is **14.4dB** for 70%TP. Despite the fact that MIMO channel model is different, we are not sure whether the test of 100MHz n260 is feasible. It may need further study.**Issue 1-2-3: Down-selecting of FR2 channel model for performance requirement**We prefer option1 as in our paper. Suggest to “adopt option 1 as baseline, and alternative channel model (InO CDL-A) can be further studied”. |
| OPPO | **Issue 1-1-1: LS on FR1 MIMO OTA**We support this LS, it is helpful to align the MIMO OTA test method.**Issue 1-2-3: Down-selecting of FR2 channel model for performance requirement**We prefer option1.**Issue 1-3-1: System implementation of 3D-MPAC**I believe some clarifications needed for our proposal. And some feedbacks reply to KS and Samsung.For Rule One, it follows the agreement of last meeting, and there is no misunderstanding. The supplementary note is that this position relationship describes the starting picture of the test procedure. With the turntable rotating to other degree, the probes is not on the z axis direction anymore.For Rule Two, it should be noted that the rule is not made for defining the initial position of the probes. The right way to use it is that, when testing one of 36 test points, using this rule to guarantee the unique relative position between the measurement probes and the DUT.To sum up, the root cause of ambiguity is that there are several coordinate systems used in 3D-MPAC system, and they are not aligned well definitely. The rules are actually defining the relationship between coordinate systems.Proposal 1a in fact obeys Rule Two with the limitation of theta range from 0 degree to 180 degree. And we agree with Proposal 1a and 1b as a sample of 3D-MPAC implementation which obey both Rule One and Rule Two.There is one missing point for Proposal 3. When testing the first test point (0.0, 0.0), there is no direction of upper hemisphere for RDI to follow. For this situation, the proposed solution is that the probe configuration in Proposal 1a can be used when testing (0.0, 0.0).**Issue 1-3-2: White Box Approach on SS-MPAC**Agree with Samsung and vivo’s opinion. Black Box approach should be the agreement for NR MIMO OTA test. |
| CAICT | **Issue 1-1-1: LS on FR1 MIMO OTA**We support the LS. RAN4 has complete the Study Item for NR MIMO OTA and TR38.827 v16.0.0 was published. This is also the first spec for NR MIMO OTA test method in industry. Currently, CTIA and CCSA are also working on FR1 MIMO OTA standardization, it would be beneficial for the industry to reach an aligned approach for performance testing in different SDOs. We believe LS would be helpful to present our views on this topic since we are way ahead of SDOs outside of 3GPP.**Issue 1-3-1: System implementation of 3D-MPAC**In my understanding, it’s difficult to judge whether P3 is satisfied when the test point aligned with the ‘pole’ position, because it is impossible to judge which direction is the upper hemisphere at this time. However, if we rotate the turntable clockwise in P1a, it seems that it obeys P3 then.We prefer to adopt a combined approach of P1a and P3. Proposal 1a can be used as a good example but other implementation is not precluded if P3 is satisfied to achieve greater freedom for test system on the basis of avoiding ambiguity. We can further discuss the specify wording of P3.In addition, if separated coordinate systems are defined, need to further clarify which coordinate system the 36 tests points defined in Table 6.2.3.2-1 are based on.**Issue 1-4-1: Channel model validation procedure**Theoretical values with base station antenna filtering effect shall be provided. Focus on high power clusters for channel model validation, consider 40dB as a starting point and further discuss the final threshold. |
| Keysight | **Issue 1-2-1: FR1 4x4 vs. 2x2 channel models***Response/Comments to vivo:*could you please clarify what is the technical justification to “replace CDL-A UMi by CDL-C UMi for 4x4”**Issue 1-3-1: System implementation of 3D-MPAC***Response/Comments to Xiaomi:* It was previously agreed and captured in 38.827 that QoQZ validation using just a single probe is sufficient, specifically D.2 (“For NR FR2 MIMO OTA, only the single-directional EIRP and EIS metrics need to be assessed and the procedure needs to be performed using just a single 3D MPAC probe.”). This approach is similar as in RRM for 2 AoA where DFF and IFF multi-probe systems require the QoQZ validation with just the single probe P0 which is aligned with the z axis/direction. For MIMO OTA, it is therefore preferred to point to 38.521-2 QoQZ procedures and place a probe in the NR FR2 MIMO OTA system the z direction. Ideally, the cluster of probes with the highest probe weights should be aligned towards the z axis to guarantee uniformly spaced DL directions perceived by UE. Performing a QoQZ validation with a probe not in the z direction, especially in the yz plane, can be complicated and tedious. We don’t believe that rotating probes requires the rotation of test points as they are already distributed uniformly. Additionally, the test points are already optimized with the maximum limited to 161.7deg which inherently limits the blocking by the positioner. *Response/Comments to vivo:* the results would be reported as a function of UE coordinates, i.e., for TP reporting, the UE coordinate system would be used. *Response/Comments to OPPO:* thanks for the clarification that Rule Two holds for test points other than (0,0); this certainly removes some ambiguities. In that case, the probe configuration in Proposal 1a would indeed be applicable. However, this would also allow one of the examples provided earlier be applicable, i.e., probes rotated towards the x axis while being mostly aligned with z axis?!Additionally, this would also allow (in either extreme) probes 3 and 6 to be centred along the z direction. Hence, this would a very wide possibility of probe configurations that should be avoided to avoid different test system implementation yielding different results.If I understand the Rule 2 properly, I believe the following probe configuration (with most probes towards z direction and oriented mainly along the xz plane with a slight tilt) would be permissible?! As far as I can tell, the RDI would point to the device’s upper hemisphere (DUT sphere in blue) for test points other than (0,0) due to the tilt. I believe this configuration will lead to vastly different results compared to the configuration in Proposal 1a and might not have been intended by OPPO’s Rules One and Two?It should furthermore be pointed out that it was previously agreed (R4-1904160) that “placement of probes for MPAC system for FR1 and FR2 have to be standardized”**Issue 1-4-2: Channel model validation limits for FR2 MIMO OTA***Response/Comments to vivo:* we assume you meant to state: “it would be helpful for readers outside of 3GPP to see both ideal curve and simulation curve of 1~~0~~6 probes model” and that this was related to FR1 (this topic discussed FR2 validation limits) |
| Qualcomm | **Issue 1-1-1: LS on FR1 MIMO OTA**In general, we support this LS. CTIA is discussing the test condition for FR1 MIMO OTA. Harmonization among the SODs is beneficial for industry.**Issue 1-2-1: FR1 4x4 vs. 2x2 channel models**Per simulation results shown in KS’s paper, proposal 1 makes more sense. Clarifications question: Is the same codebook used for UMi and UMa channel model in the simulation? We might also need to consider the possibility of CDL-A UMa for 2\*2 and CDL-C UMi for 4\*4 since UMa with 2\*2 for larger coverage makes more sense.**Issue 1-2-2: Down-selecting of FR2 RMC for performance requirement**We agree to adopt 16QAM RMC as the only RMC for all the bands. If feasibility issues are identified for higher band, other approach can be further considered. RAN4 to check the feasibility of 64QAM based on the technical input from companies.Response to vivo’s comments on achievable SNR calculation:We believe the CE loss mentioned by vivo has been considered in achievable SNR calculation for single probe. The TE output power in the spreadsheet of TR38810 should be the output power after CE. Note that for FR2 Demod and RRM testing, we consider the TDL fading channel which means CE has been considered when deriving the achievable SNR in TR38810. **Issue 1-2-3: Down-selecting of FR2 channel model for performance requirement**We prefer option 2 to increase the test coverage for FR2. Moreover, it aligns with the capability of 3D-MPAC (Agreed to use 6 probes to support CDL-A and CDL-C channel model). We can set the priority for one channel model to solve the concerns from companies on WI competition.**Issue 1-3-1: System implementation of 3D-MPAC**Proposal 2a will change probe layout optimized in the SI which will lead to the degradation on PSP.**Issue 1-3-2: White Box Approach on SS-MPAC**RAN4 has agreed to use black box approach for OTA testing. Further study on white box approach is needed before introducing in MIMO OTA. |
| Spirent | **Issue 1-2-1: FR1 4x4 vs. 2x2 channel models****Spirent supports Keysight’s proposal****Issue 1-4-1: Channel model validation procedure****Spirent supports the [40dB] threshold as a starting point.**  |
| Huawei  | **Issue 1-2-2: Down-selecting of FR2 RMC for performance requirement***Response/Comments to vivo:* not sure about the statement that “*these papers are all not correct*”, regarding “*the internal/physical path loss of Channel emulator*”, should it already be taken into account in TE output power? Similar calculations have been used in FR2 demodulation/RRM tests. What more important is that I trust the expertise of my friends from QC, Samsung and other honourable companies.Regarding the “25 or 20MHz bandwidth for n260” in Option 2, I know that the minimum bandwidth in FR2 FRC in 38.101-4 Table 7.2.2.2.1-4 is 50MHz (R.PDSCH.5-5.2 TDD), but according to our analysis, “the feasible SNR **SNR3D-MPAC ~ 11.8+[0, 3.5]dB** for n260 of 100MHz bandwidth” which may not be enough to support 16QAM @70TP. Even with 3dB gain by reducing to 50MHz, we are still not sure about the feasibility. Therefore we also considered the possibility of further reducing bandwidth beyond 38.101-4, i.e. 25 or 20MHz bandwidth for n260.  |
| OPPO | **Issue 1-3-1: System implementation of 3D-MPAC**Response to KS:Regarding the question of rotating the probes towards the x axis, the answer is YES, it is another example of the system implementation. The reason is that the relative position between the probes and the DUT is essentially not changed. This relative position is what should be standardized indeed, not only the starting picture of the implementation. As CAICT mentioned, it is a good thing to leave greater freedom to test system on the basis of the uniqueness of the relative position between the probes and the DUT on every 36 test points.KS’s second concern is reasonable. Which probe centred along Z direction should be clarified. We do not have strong view on it. The Proposal 1a that putting Probe 1 on the centre is a preferable placement.For the sample of “most probes towards z direction and oriented mainly along the xz plane with a slight tilt”, I’m sorry that it is not permissible. The sample does not obey the Rule 2 strictly. The Rule 2 has two requirements, i.e. the first one is “keep the Reference Direction Indicator along the longitude line on DUT spherical surface”, the second one is “pointing to upper hemisphere”. Obviously, the sample does not meet the first requirement.So, we believe that Proposal 3 is a useful method to check the system implementation whether satisfying the test objective or not, with some supplementations, i.e. the placement definition on (0,0) position, the probe to be centred along the z direction. |

### CRs/TPs comments collection

*Major close-to-finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| R4-2016218(TP) | Company A |
| Company B |
|  |
| R4-2016221(TP) | Company A |
| Company B |
|  |
| R4-2016222(TP) | Company A |

## 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** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

*Recommendations 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 provides recommendation on CRs/TPs Status update*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*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**  |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #2: Performance Requirements

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2015311 | CAICT, vivo | “Framework on NR MIMO OTA requirements development”**Proposal 1: Labs volunteer to participate in the performance requirement part shall complete the lab alignment measurements and submit the results to RAN4 for review.****Proposal 2: Lab alignment activities shall be divided in two independent parts. Part 1: lab alignment for FR1; Part 2: lab alignment for FR2 (if applicable). Simulation approach for FR2 requirement development is not precluded.****Proposal 3: Vendors or labs shall complete the channel model validation in accordance with the requirements of the above items during lab alignment activities.****Proposal 4: Labs shall complete the calibration and performance alignment in accordance with the requirements of the above items during lab alignment activities.****Proposal 5: Results for FR1 lab alignment activities shall be reported in the approved format, as specified in Table 2.4.1-1.****Proposal 6: Select sufficient commercial devices in the market, smartphone is the first priority. The measurement result of these selected devices shall be submitted by the aligned labs.****Proposal 7: Decide the minimum number of devices (e.g., at least [15]) for defining requirements in each band.** |
| R4-2016588 | Huawei, HiSilicon | “Discussion on framework for the definition of NR MIMO OTA TRMS requirements”**Proposal 1: adopt above framework for the definition of NR MIMO OTA TRMS requirements (with track changes accepted).** |
| R4-2014723 | Samsung | “Discussion on FR1 and FR2 MIMO OTA”**Observation 1: the precondition for defining exception points is to specify the PRS-EPRE-MAX (maximum downlink RS-ERPE) parameter.****Proposal 1: PRS-EPRE-MAX (maximum downlink RS-ERPE) parameter shall be specified for FR1 NR MIMO OTA. Further discussion is needed if -80dBm/15kHz or equivalent (-77dBm/30kHz) could be re-used for whole NR FR1 range.****Proposal 2: exception points shall be specified for FR1 NR MIMO OTA at both 70%TP and 95%TP****Observation 2: Option 1 (TP@90% can pass 11 of total 12 rotations) is even more stringent than the LTE exception point requirement at 70%TP (TP@70% can pass 11 of total 12 rotations).****Proposal 3: Option 2 (TP@95% can pass 10 of total 12 rotations) is only acceptable for below 3GHz.****Observation 3: if [50%] percentile value is also taken as a FoM, that means no exception points allowed for all top [50%] test points.****Proposal 4: For NR MIMO OTA, only middle channel shall be verified for each band.** |
| R4-2016219 | vivo, CAICT | “Discussions on FR2 MIMO OTA requirements”**Observation 1: Throughput outage of the FR2 PMODE is not defined yet.** **Observation 2: Limited DL power of FR2 system has impacts on throughput testing of different UE orientations.** **Proposal 1: Align with demodulation test cases and FR1 MIMO OTA, 70% of maximum throughput as outage could be the starting point for FR1 MIMO OTA requirements.** **Proposal 2: RAN4 should define the final outage of throughput for FR2 MIMO OTA requirements based on measurement results of real devices.** **Proposal 3: Decision should be made on how to treat the orientations those can not reach target outage throughput in the future.**  |
| R4-2016235 | Qualcomm Incorporated | “Views on for FR2 MIMO OTA”**Observation 3: The approach of averaging MIMO sensitivity better than certain percentile of CCDF e.g. 50% for PC3, can be selected as the FoM for FR2 MIMO OTA requirement.****Observation 4: EIS statistics mode deviates from the orginal EIS CCDF as down sampling rate increase. Compared with orignal data and 18 samples (equivalent to 36 samples in whole sphere), the deviations are nontrivial.** **Observation 5: Based on the EIS measurements analysis, 36 grid points will lead to ~0.77dB MU on averaging sensitivity which is much larger than TRP MU of 0.25dB.** **Proposal 3: RAN4 to consider more test points to make sure the MU of MIMO OTA performance requirement is less than 0.25dB.** |
| R4-2016589 | Huawei, HiSilicon | “Discussion on open issues of NR MIMO OTA WI”**Proposal 1: in addition to the agreement that *“Only one outage point of TP@ 70% is selected for the final performance metric”,* select option 2 in the WF as another check point i.e. “*TP@95% can pass 10 of total 12 rotations”.*****Proposal 2: clarify the agreement as “select averaging all the value better than [xx%, “xx” is the %-tile of spherical coverage requirements for different power classes] percentile of CCDF as the only Figure of Merit for FR2 MIMO OTA requirement”. And not to introduce “[50%] percentile of the CCDF curve” as another FoM.** |
| R4-2015352 | OPPO | “Analysis on the impact of number of test points”**Proposal:** **keep the agreement of 36 evenly spaced test points for FR2 MIMO OTA test.** |
| R4-2016539 | Huawei, HiSilicon | “Simulation assumptions for NR FR2 MIMO OTA”**Proposal 1: BS beamforming configuration shall be described in more detail. We prefer to use option1 for FR2 BS beamforming configuration.****Proposal 2: The number of clusters shall be clearly regulated in different scenarios. We prefer Option 3.****Proposal 3: adopt two simplified antenna array layouts (two 2x2 patches and three 1x4 patches with the display) to evaluate on UE performance.** |
| R4-2014829 | MediaTek Inc. | “Proposal of FR2 MIMO OTA simulation approach workplan”**Proposal 1: Approve FR2 MIMO OTA simulation approach workplan as Fig 1. i.e.****• RAN4#99-e (May, 2021): agree on simulation setting****• RAN4#100 to RAN4#101 (Aug to Nov, 2021): simulation data collection** |

## Open issues summary

### Sub-topic 2-1 Framework on performance requirements development

**Issue 2-1: Framework on performance requirements development**

* Proposal 1: Adopt framework on NR MIMO OTA TRMS performance requirements development in [R4-2015311].
* **P1**: Labs volunteer to participate in the performance requirement part shall complete the lab alignment measurements and submit the results to RAN4 for review.
* **P2**: Lab alignment activities shall be divided in two independent parts. Part 1: lab alignment for FR1; Part 2: lab alignment for FR2 (if applicable). Simulation approach for FR2 requirement development is not precluded.
* **P3**: Vendors or labs shall complete the channel model validation in accordance with the requirements of the above items during lab alignment activities.
* **P4**: Labs shall complete the calibration and performance alignment in accordance with the requirements of the above items during lab alignment activities.
* **P5**: Results for FR1 lab alignment activities shall be reported in the approved format, as specified in Table 2.4.1-1.
* **P6**: Select sufficient commercial devices in the market, smartphone is the first priority. The measurement result of these selected devices shall be submitted by the aligned labs.
* **P7**: Decide the minimum number of devices (e.g., at least [15]) for defining requirements in each band.
* Proposal 2: Adopt framework on NR MIMO OTA TRMS performance requirements development (with change tracks accepted) in [R4-2016588].
* Only aligned MIMO OTA labs can share measurement results into TRMS data pool
* **P1:** MIMO OTA TRMS requirements for FR1 are derived from measurement results of commercial devices. For FR2, simulation approach to define performance requirement is FFS.
* **P2**: The 8 bands listed in WID have highest priority:
	+ - FR1: Band n41, n77, n78 and n79
		- FR2: Band n257, n258, n260 and n261
* **P3**: For a given frequency band, the requirement is defined based on the available data (≥15 TRMS points);
* **P4:** Whether joint band passing rate or per band approach is used for defining the requirements for above bands is to be determined
* **P5**: for FR1, each sample shall support at least 3 different NR bands, such that at least 1 low band (<3 GHz) and 1 high band (>= 4 GHz). For FR2, it is FFS.
* **P6**: The following percentile is picked from the overall TRMS CDFs for requirements:
	+ - For FR1 TRMS at 70%TP: 85 percentile of the CDFof TRMSaverage,70
		- For FR2, it is FFS.
* **P7**: If measurements are not provided for some of the bands, the WI can finalize the requirements for those bands for which data is available according to P3
* **P8**: the number and location of all bands each UE supports shall be provided for information when TRMS data are provided
* **P9**: at RAN4#100 aim is to agree TRMS requirements for all above FR1 bands listed in WID; at RAN4#101 aim is to agree TRMS requirements for all above FR2 bands listed in WID; additional bands are not precluded
* **P10**: measurement results of SA mode are the first priority, NSA mode results are also encouraged. Information of SA or NSA mode shall be provided together with measurement data.
* Proposal 3: For NR MIMO OTA, only middle channel shall be verified for each band.
* Recommended WF
	+ TBA

### Sub-topic 2-2 Performance metric for FR1 MIMO OTA

**Issue 2-2-1: Maximum downlink RS-EPRE for FR1 MIMO OTA performance metric**

* Proposals
	+ Proposal 1: PRS-EPRE-MAX (maximum downlink RS-ERPE) parameter shall be specified for FR1 NR MIMO OTA.
		- Option 1: -80dBm/15kHz
		- Option 2: -77dBm/30kHz
		- Option 3: other
* Recommended WF
	+ TBA

**Issue 2-2-2: Exception points for FR1 MIMO OTA performance metric**

* Proposals
	+ Proposal 1: Exception points shall be specified for FR1 NR MIMO OTA at both 70%TP and 95%TP.
	+ Proposal 2: Select “TP@95% can pass 10 of total 12 rotations” as another check point.
	+ Proposal 3: “TP@95% can pass 10 of total 12 rotations” is only acceptable for below 3GHz.
* Recommended WF
	+ TBA

### Sub-topic 2-3 Performance metric for FR2 MIMO OTA

**Issue 2-3-1: outage throughput for FR2 MIMO OTA performance metric**

* Proposals
	+ Proposal 1: As starting point, adopt 70% of maximum throughput value as outage point.
	+ Proposal 2: RAN4 should define the final outage of throughput for FR2 MIMO OTA requirements based on measurement results of real devices.
	+ Proposal 3: Decision should be made on how to treat the orientations those can not reach target outage throughput in the future.
* Recommended WF
	+ TBA

**Issue 2-3-2: averaging approaches for FR2 MIMO OTA performance metric**

* Proposals
	+ Proposal 1: clarify the agreement as “select averaging all the value better than [xx%, “xx” is the %-tile of spherical coverage requirements for different power classes] percentile of CCDF as the only Figure of Merit for FR2 MIMO OTA requirement”.
	+ Proposal 2: not to introduce “[50%] percentile of the CCDF curve” as another FoM.
* Recommended WF
	+ TBA

**Issue 2-3-3: Number of test points for FR2 MIMO OTA performance metric**

* Proposals
	+ Option 1: RAN4 to consider more test points to make sure the MU of MIMO OTA performance requirement is less than 0.25dB.
	+ Option 2: Keep the agreement of 36 evenly spaced test points for FR2 MIMO OTA test.
* Recommended WF
	+ TBA

### Sub-topic 2-4 Simulation issues for FR2 performance evaluation

**Issue 2-4-1: simulation approach work plan for FR2 MIMO OTA**

* Proposals
	+ Proposal 1: Approve FR2 MIMO OTA simulation approach workplan as Fig 1 in R4-2014829, i.e.

• RAN4#99-e (May, 2021): agree on simulation setting

• RAN4#100 to RAN4#101 (Aug to Nov, 2021): simulation data collection.

* Recommended WF
	+ TBA

**Issue 2-4-2: Simulation assumption for FR2 performance evaluation**

* Proposals
	+ Option 1:
* **BS beamforming configuration:** We select the strongest beam from the codebook of 128 fixed beams, and then rotate the BS antenna array so that the direction of this beam towards the strongest cluster (Clsuter #6 in UMi CDL-C and Clsuter #2 in InO CDL-A).
* **Number of clusters:** choose 3 or 4 strongest clusters, i.e. 3 for CDL-A as cluster #2, #3 ,#4, 4 for CDL-C as cluster #6, #7, #8 ,#2, for each channel model that the BS strongest beam toward to.
* **PSP:** comparison between these above clusters(3 for CDL-A as cluster #2 #3 #4, 4 for CDL-C as cluster #6 #7 #8 #2) radiated from 6 probes and reference PAS from the above clusters defined in the channel model.
* **UE antenna array:** adopt two simplified antenna array layouts (two 2x2 patches and three 1x4 patches with the display) to evaluate on UE performance.
	+ Option 2: other
* Recommended WF
	+ TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Keysight | **Issue 2-4-2: Simulation assumption for FR2 performance evaluation****BS beamforming configuration:** we agree that the text in 7.3: “*1 strongest transmitting beam is generated from BS, the direction of this beam towards the strongest cluster of each FR2 channel model*” should be updated. It should say “*1 strongest transmitting beam out of the 128 beam fixed beam grid is selected for each FR2 channel model*”* **Number of clusters:** Option 2 in R4-2016539 is based on originally accepted proposal and our preference is not to make a late change as existing model and validation implementations are already based on previously agreed method unless there is a strong compelling case for this change
* **UE antenna array:** Our view is not to define antenna array locations given the black box approach. Method of uniform sampling grid within the test-zone has been used so far and should be used in future as well to provide overview of all test orientations by one simulation. 2x2 and 1x4 arrays are subsets of the 4x4 array, which should be used in the simulations. 1x4 array is not suitable for PSP simulation as it reduces the channel model into 2D. Symmetrical rectangular arrays should be used in PSP simulations.
 |
| Xiaomi | **Issue 2-2-2: Exception points for FR1 MIMO OTA performance metric**For FR1 we think it is quite mature now so we prefer proposal 3.**Issue 2-3-1: outage throughput for FR2 MIMO OTA performance metric**Prefer proposal 2 to see more results of the real devices. |
| Samsung | Sub-topic 2-1 Framework on performance requirements development**Issue 2-1: Framework on performance requirements development**Agree on the proposal that minimum number of devices should be guaranteed and the UE should support low and high bands (multi-band UE), e.g. FR1 UE supports both n41 and n79, FR2 UE support both 28GHz and 39GHz. Single-band UE or UE that covers narrow frequency range should be precluded.Besides, we propose to agree on the test channel i.e. only middle channel for each band, which follows the principle of LTE MIMO OTA. It will also be beneficial for the measurement campaign afterwards.Sub-topic 2-2 Performance metric for FR1 MIMO OTA**Issue 2-2-1: Maximum downlink RS-EPRE for FR1 MIMO OTA performance metric**We propose to specify PRS-EPRE-MAX (maximum downlink RS-ERPE) parameter before specify exception points requirements. We are open to each option. -80dBm/15kHz and equivalent -77dBm/30kHz may be starting point.**Issue 2-2-2: Exception points for FR1 MIMO OTA performance metric**We support proposal 1, i.e. exception points should be applicable for both 70%TP and 95%TP. For proposal 2 and proposal 3, the precondition is the value of PRS-EPRE-MAX (maximum downlink RS-ERPE). At current stage, we can keep it TBD for whole FR1 range or restrict proposal 2 and proposal 3 within 3GHz.Sub-topic 2-3 Performance metric for FR2 MIMO OTA**Issue 2-3-1: outage throughput for FR2 MIMO OTA performance metric**The proposals are all reasonable. 70% outage is a good starting point. Especially FR2 high bands (39GHz etc.) should be paid more attention for which achievable SNR is limited. There is also open issue on maximum downlink signal level definition and allowable exception points.**Issue 2-3-2: averaging approaches for FR2 MIMO OTA performance metric**We support the proposals. Agree to consider averaging approach as only metric, the clarification in proposal 1 is also meaningful.**Issue 2-3-3: Number of test points for FR2 MIMO OTA performance metric** We support option 2, i.e. keep the agreed 36 test points. MU larger than 0.25dB for OTA test especially receiver OTA test is acceptable. And the MIMO OTA averaging approach will provide better MU than EIS.Sub-topic 2-4 Simulation issues for FR2 performance evaluation**Issue 2-4-2: Simulation assumption for FR2 performance evaluation**About UE antenna array, typical implementation for PC3 is two panels. 3 panels is possible in implementation but should be precluded in simulation assumption. |
| vivo | Sub topic 2-1: **Issue 2-1: Framework on performance requirements development**Given the FR2 test method is not stable yet, the lab alignment activity should be limited to FR1. After making progress on FR1, further conclusions can be made on FR2 by a similar approach. For FR2 prefer to align simulation assumptions first. Sub topic 2-2:**Issue 2-2-1: Maximum downlink RS-EPRE for FR1 MIMO OTA performance metric**First, the Maximum output power of gNodB is Full cell power, that means the maximum downlink RS-EPRE is related to the channel bandwidth, which should be 6dB lower for 40MHz band compare to 10MHz band. Second, the end-to-end path loss of a typical OTA chamber at n79 is about 6dB higher than n41, so it is reasonable to set a seperate maximum output power for frequency <3GHz and frequency >3GHz.Further check the maximum downlink power is needed.**Issue 2-2-2: Exception points for FR1 MIMO OTA performance metric**As discussed in our previous contribution, the 95% point of the throughput is not stable, large variation with poor repeatability might show. So, we prefer to define exception points at both 70%TP (11 of total 12 rotations) and 90%TP (10 of total 12 rotations), for frequency bands below 3GHz. Further study the exception points for bands above 3GHz.Sub topic 2-3:**Issue 2-3-1: outage throughput for FR2 MIMO OTA performance metric**Specify 70% of maximum throughput value as outage point. Further discuss higher TP and Exception points for FR2 MIMO OTA based on more input (simulation or measurement).**Issue 2-3-2: averaging approaches for FR2 MIMO OTA performance metric**In the WID, *Smartphone is the first priority*, we prefer to focus on smartphone first (50% tile), and then other device type. However, we are OK to align with EIS spherical coverage to set different value for other PCs. Support P2.**Issue 2-3-3: Number of test points for FR2 MIMO OTA performance metric**Support option 2, keeping the agreed 36 test points. Further discuss whether an additional MU element named as “uncertainty of number of measurement points” is needed, and specify a preliminary value for this element if needed.Sub topic 2-4:**Issue 2-4-1: simulation approach work plan for FR2 MIMO OTA**Before going into detailed workplan for FR2 simulation, RAN4 group needs to reach consensus on whether simulation analysis is playing dominant role for specifying requirements, like RAN4’s action on defining FR2 EIRP/EIS spherical coverage requirement, or is just auxiliary approach on top of measurement results.**Issue 2-4-2: Simulation assumption for FR2 performance evaluation**Regarding the proposed Number of clusters, are these cluster selected from Channel models after BS pattern filtering? In my understanding this simulation is the estimation of UE throughput performance with different channel model under different DL power level, why we need to compare the PSP.If the intention is also for channel model pass/fail limits simulation, then we should separate the discussions. |
| Huawei  | **Issue 2-2-2: Exception points for FR1 MIMO OTA performance metric**We are fine with proposal 1, maybe we can try to see whether it is possible to have the agreement that (similar as LTE MIMO OTA in 37.144)* In addition to the agreement that *“Only one outage point of TP@ 70% is selected for the final performance metric”,* Select “TP@95% can pass 10 of total 12 rotations” as another check point.
* For outage point of TP@ 70%, One exception point is allowed for 12 rotations of each Mode of {*FS\_DMP, FS\_DML, FS\_DMSU*}, i.e. if 1 azimuth position does not result in a defined measured sensitivity at 70% throughput, *SMODE,70*is calculated using the 11 measured sensitivities and the maximum downlink RS-EPRE *PRS-EPRE-MAX* (substitution approach) for the one missing result.
* Above two bullets are agreed for the frequency range below 3GHz, whether it is also applicable for frequency range above 3GH is FFS.

**Issue 2-3-3: Number of test points for FR2 MIMO OTA performance metric** We prefer option2. And thank QC for providing very good testing result in R4-2016235, the difference of 0.77dB between the tests of 36 points and “constant step grid with step size of 15 degrees” seems good (not large) in terms of testing variation of MIMO OTA. |
| OPPO | **Issue 2-3-2: averaging approaches for FR2 MIMO OTA performance metric**We support Proposal 2 to make the performance metric simple and effective.**Issue 2-3-3: Number of test points for FR2 MIMO OTA performance metric** We prefer option2.  |
| CAICT | **Issue 2-1: Framework on performance requirements development**Before starting data collection, it is important for the group to reach a consensus on how to formulate the final performance limits for the smooth progress of the WI. Companies views on detailed lab alignment procedures are encouraged.Requirements of FR1 and FR2 will be discussed separately. Considering we still have some open issues on FR2 core part, we can further update the FR2 framework based on the conclusions of the discussion. **Issue 2-3-1: outage throughput for FR2 MIMO OTA performance metric**We support the proposals. Select 70% of maximum throughput as outage point at current stage. If measurement results demonstrate that 70%TP is not reasonable, we can review this issue again in the future.**Issue 2-3-3: Number of test points for FR2 MIMO OTA performance metric** We prefer option 2.  |
| Qualcomm | **Issue 2-1: Framework on performance requirements development**Regarding the measurement approach, the min. number of devices for FR2 should be less than that for FR1 i.e. 15 devices considering FR2 industry status. Another question is how to proceed if both simulation and measurement results are submitted by companies? **Issue 2-2-2: Exception points for FR1 MIMO OTA performance metric**The same principle for exception points for LTE MIMO OTA should be reused for FR1 MIMO OTA. Decision should be made based measurement results.**Issue 2-3-1: outage throughput for FR2 MIMO OTA performance metric**Agree with that 70% of maximum throughput value as the starting point and further study the outage of T-put based on measurements results.**Issue 2-3-2: averaging approaches for FR2 MIMO OTA performance metric**Agree with the proposals.**Issue 2-3-3: Number of test points for FR2 MIMO OTA performance metric** Before we decide if more test points are needed, RAN4 should analyse the MU with current agreements of 36 test points as what we did for EIS/TRP/EIRP measurement grids analysis. The results shown in our paper is based on the measurement for one device. To derive the MU, simulation is needed.**Issue 2-4-1: simulation approach work plan for FR2 MIMO OTA** Clarification question: how to proceed if both measurement results and simulation results are provided from companies?**Issue 2-4-2: Simulation assumption for FR2 performance evaluation**The channel parameters specified in TR38827 has considered the BS beamforming configuration and number of clusters. The simulation should be based on the parameters defined in TR38827. It is not clear how to emulate channel with certain PSP in the simulation. Or we don’t need to consider PSP/probe layout in the simulation approach.The proposed UE antenna array is coming from Rel-15 discussion. Now we are discussing Rel-17 MIMO OTA requirements. Need input from companies on the new UE antenna array assumptions. |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## 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.*

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|  | **Status summary**  |
| **Sub-topic#1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

*Suggestion on WF/LS assignment*

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

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

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| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

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

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| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #3: TR 38.827 maintenance

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2014289(CR) | Spirent Communications | CR: Addition of Time Domain Alternative for Spatial Correlation Validation |
| R4-2016227 | vivo, CAICT | Number of slots for NR MIMO OTA testing**Observation 1: Number of Slots per stream for FoM measurement is not defined for NR MIMO OTA.** **Observation 2: minimum number of 10000 subframe is sufficient to identify the LTE MIMO OTA performance.** **Proposal 1: Adopt 20000 as the minimum number of slots per stream for NR MIMO OTA testing.** **Proposal 2: Further discuss whether 20000 slots is sufficient for 120kHz SCS FR2 MIMO OTA testing.****Proposal 3: If non-negligible variation of throughput is identified, the number of slots might be increased or new MU element named as “uncertainty associated with the number of slots” might need to be added into FR2 MU budget.** **Proposal 4: Further study whether the minimum number of slots for FR1 MIMO OTA could be reduced to 10000, measurement results or simulation analysis for FR1 MIMO OTA performance is encouraged.** |
| R4-2016228(CR) | vivo | CR: Number of Slots for NR MIMO OTA testing |
| R4-2016586(CR) | Huawei, HiSilicon | CR: CR for 38.827 on corrections |
| R4-2006544(TP) | Huawei, HiSilicon | TP to 38.827 on channel model rotations |
| R4-2016546(TP) | Huawei, HiSilicon | TP to 38.827 on base station beamforming configuration |
| R4-2016211(reserved) | Keysight Technologies | CR: Update of FR2 probe configuration |

## Open issues summary

### Sub-topic 3-1 Number of slots for NR MIMO OTA testing

**Issue 3-1: Number of slots for NR MIMO OTA testing**

* Proposals
	+ Proposal 1: Adopt 20000 as the minimum number of slots per stream for NR MIMO OTA testing.

For FR2,

* + Proposal 2: Further discuss whether 20000 slots is sufficient for 120kHz SCS FR2 MIMO OTA testing.
	+ Proposal 3: If non-negligible variation of throughput is identified, the number of slots might be increased or new MU element named as “uncertainty associated with the number of slots” might need to be added into FR2 MU budget.

For FR1,

* + Proposal 4: Further study whether the minimum number of slots for FR1 MIMO OTA could be reduced to 10000, measurement results or simulation analysis for FR1 MIMO OTA performance is encouraged.
* Related CR: R4-2016228
* Recommended WF
	+ TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Keysight | **Issue 3-1: Number of slots for NR MIMO OTA testing** * Based on our analyses, the proposed number of slots for FR2 is acceptable. However, we believe that the emulation length should be longer than 20k slots for FR1, specifically SCS of 30kHz. We could provide such table to outline the number of slots as a function of SCS and frequency if requested.
 |
| Samsung | **Issue 3-1: Number of slots for NR MIMO OTA testing** Agree to specify the exact number of slots. Generally speaking 20000 slots is a good proposal at current stage. If possible 10000 slots is also an option and we’d better be careful to further increase slots number beyond 20000. As proposal 3 mentioned, if non-negligible issue identified, new MU element named as “uncertainty associated with the number of slots” is a possible way forward. |
| vivo | **Issue 3-1: Number of slots for NR MIMO OTA testing** Indeed, the emulation time period for 30kHz SCS becomes smaller, however, we would like to see more analyses of the impacts. We agree with the comments from Samsung. |
| CAICT | **Issue 3-1: Number of slots for NR MIMO OTA testing**We agree with the views from Samsung and vivo. 20000 slots could be a good starting point for NR MIMO OTA to ensure that laboratories can use the same settings for performance measurement.We have compared the test results of 20000 and 10000 slots for LTE MIMO OTA in the past, and the difference is very small. Although 30kHz SCS for FR1 may have an impact on this conclusion, we believe further discussion on whether number of slots can be reduced is needed after we have some measurement or simulation input. |
| Keysight | **Issue 3-1: Number of slots for NR MIMO OTA testing**Our proposal for the suggested min. number of slots is based on the analysis we performed originally in for LTE (R4-111381) and the recommendation: “we recommend that at least 1000 is emulated in MIMO OTA.” The table below outlines the min number of slots for various sample frequencies, UE velocities, SCS.

|  |  |  |
| --- | --- | --- |
| **Frequency Range** | **FR1** | **FR2** |
| **SCS [kHz]** | **30** | **30** | **30** | **30** | **120** | **120** |
|  ***f* [GHz] *v* [km/h]** | **0.6** | **2.1** | **3.5** | **6.5** | **26** | **41** |
|
| **3** |   |   |   |   | 110769 | 70244 |
| **12** |   |   |   |   | 27692 | 17561 |
| **30** | 120000 | 34286 | 20571 | 11077 | 11077 | 7024 |

 |
| Qualcomm | **Issue 3-1: Number of slots for NR MIMO OTA testing** Agree with proposal 1 and 2.For proposal 3, we prefer not to introduce additional MU for number of test points. |

### CRs/TPs comments collection

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| **CR/TP number** | **Comments collection** |
| R4-2014289 | Keysight: Our preference would be to add more accurate instrument settings and synchronization procedure (cabling etc.) as it might not be clear to everyone |
| Spirent: Answer to Keysight: In our view, the instrument settings are complete (no other parameter is needed), and the cabling is also complete (no other cabling is required). The synchronization procedure is clearly stated in the text: “For each spatial point, the channel emulator should issue a trigger signal each time fading is started” |
|  |
| R4-2016228 | Company A |
| Company B |
|  |
| R4-2016586 | Moderator: “Postponed”CR cover page version is not correct. WI code is not correct. Need to come back next meeting based on RAN4 Chair’s guidance:“All CRs, for both open or closed WIs, will be automatically postponed to the next meeting if there are two or more errors on the CR coversheet”Views on the content can be discussed |
| CAICT: Add some additional corrections. Maybe we can consider fixing these problems together in this CR.- In section 7.1, “FR1 UMi CDL-A in table 7.1.1-1” should be “FR1 UMi CDL-A in table 7.2.1-1”- Annex B.2.2 has a numbering error (from B.2.2.2 to B.2.2.16). In addition, the content of Annex B.2.2.12 and B.2.2.15 are completely duplicated. |
|  Huawei: thank CAICT for kindly providing the improvements. I will add them to the revised version which will come back in next meeting with correct format :) |
|  |
| R4-2016544 | Moderator: “Postponed”TDoc type should be CR, come back next meeting. Views on this topic can be discussed. |
| Keysight: The channel model rotation will change depending on revised probe locations and channel model coordinate system definition and will be double checked |
| Company B |
|  |
| R4-2016546 | Moderator: “Postponed”TDoc type should be CR, come back next meeting. Views on this topic can be discussed. |
| Keysight: given channel model and validation implementations have been based on the previously agreed implementation, it is preferred not to make a late change unless there is a strong compelling case for this change |
| Company B |
|  |

## Summary for 1st round

### Open issues

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|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic#1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

*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**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*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**  |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Refrenece

[1] RP-201998, SR for NR\_MIMO\_OTA，RAN#89-e, Sep. 2020

[2] R4-2012707, WF on MIMO OTA, vivo, CAICT, Spirent, RAN4#96-e, Aug. 2020

[3] R4-2016539, Simulation assumptions for NR FR2 MIMO OTA, Huawei, HiSilicon, RAN4#97-e, Nov. 2020