**3GPP TSG-RAN WG4 Meeting #94-e R4-20xxxxx**

**Electronic Meeting, Feb.24th – Mar.6th 2020**

**Agenda item:** 10.2.1

**Source:** CAICT

**Title:** Email discussion summary for RAN4#94e\_#97\_FS\_NR\_MIMO\_OTA\_test

**Document for:** Information

# Introduction

In the last RAN4 meeting, the actions for finalizing FR2 MIMO OTA were agreed in the WF [1]:

*Actions for finalizing FR2 MIMO OTA：*

* + *Channel model and Quality of Quiet Zone validation procedures:*
		- *TPs to finalize FR2 channel model validation procedure and quiet zone validation procedure*
	+ *3D MPAC calibration and test procedures:*
		- *TPs to finalize calibration and test procedures*
	+ *MU assessment*
		- *Define key elements and descriptions*
	+ *Study feasible SNR ranges for 3D MPAC*
		- *Provide FR2 SNR analysis based on whole 3D-MPAC system*
	+ *UE Direction of Travel for FR2 channel models*
		- *Make decision on DoT for FR2, based on the same approach for FR1 in [R4-1915060]*
	+ *CE vendors align on channel model tap resolution*
		- *Initial phase definition of channel model shall be studied*

In the RAN plenary meeting, the NR MIMO OTA SI was approved to extend to March 2020 [2]. This is the last RAN4 meeting to finalize all the FR2 MIMO OTA open issues.

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

* 1st round: make decision on the open issues for FR2 NR MIMO OTA, update the TPs based on the comments.
* 2nd round: finalize the content of TPs for each open issue of FR2 MIMO OTA.

# Topic #1: FR2 test methods

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2000505 | Qualcomm Incorporated | Proposal: Capture SNR upper bound values in Table 2 and attached calculator in TR38.827.**Table 1: SNR upper bound value for MIMO OTA with measurement distance of 0.75m**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Channel Bandwidth** | **Maximum SNR with 1 probe** | **Maximum SNR with 8 probe3** |
| Multi-band UE (Note) | 100 MHz | [24.4dB] | [33.4dB] |
| Note 1: For ∑MBp from TS 38.101-2 Table 6.2.1.3-4 allow up to 2 dB.Note 2: The SNR is calculated based on the UE noise floor derived by REFSENS.Note 3: Compared with 1 probe, 8 probes can reach up to 9dB gain. |

Observation 1: The SNR upper bound for MIMO OTA with 8 probes is 33.4dB for 100MHz channel bandwidth. |
| R4-2000894 | CAICT | TR38.827 v1.1.0 NR MIMO OTA |
| R4-2000896 | CAICT | TP to TR 38.827 v1.1.0 on FR2 preliminary MU assessment |
| R4-2000897 | CAICT | TP to TR 38.827 v1.1.0 on general part |
| R4-2002073 | Spirent Communications | Proposal 1: Agree on 6 probes, 3 per scaled channel model, in FR2 MPAC MIMO OTA to be minimum number of probes.Proposal 2: Use table 1 to place probe 1 in chamber for each channel model. Adjacent probes will be placed by optimizing the locations and weights.Proposal 3: Adopt the table 2 probe locations with target PSP values.Observation 1: CDL-A InO is single cluster model, while CDL-C UMi has two significant clusters. |
| R4-2002074 | Spirent Communications | TP for System Design and Probe layout for FR2 MPAC MIMO OTA |
| R4-2002100 | Spirent Communications | Proposal 1: Adopt the simplified two step validation technique to FR2 channel model validation. |
| R4-2002102 | Spirent Communications | TP for Verification of FR2 channel models in MPAC system |
| R4-2002365(rev of R4-2002102) | Spirent Communications | Revised TP for Verification of FR2 channel models in MPAC system |
| R4-2002117 | ROHDE & SCHWARZ | Proposal 1: Whether to utilize a DFF or IFF system is left up to the system implementation. Only the figure of merit and measurement uncertainty are defined.Proposal 2: Specific system implementation details like the antenna position and number of antennas are defined separately for each system type (DFF/IFF).Observation 1: IFF are preferred over DFF systems for RF/RRM/Demod testing.Observation 2: For RF testing IFF systems provide smaller uncertainties than DFF systems and a higher SNR range.Observation 3: It is only important for a test system to meet the specified figure of merit. |
| R4-2002151 | Keysight Technologies UK Ltd | TP to TR38.827: FR2 MIMO OTA Calibration and Test Procedures |
| R4-2002152 | Keysight Technologies UK Ltd | TP to 38.827 to introduce EUT orientations for FR2 |
| R4-2002153 | Keysight Technologies UK Ltd | Observation 1: For a single-probe setup, the maximum achievable SNR is ~17.4dB.Observation 2: The SNR increase due to the multi-probe configuration for the simplified assumption used in this contribution is ~3.5dB.Observation 3: The estimated maximum achievable SNR for the N probe system with the assumptions made in this contribution is ~20.9dB. |
| R4-2002154 | Keysight Technologies UK Ltd, Spirent Communications | Observation 1: The PSP simulations between the two CE vendors that have provided PSP simulations in the past are aligned, with some additional comparisons in progressObservation 2: Beamforming assumptions are aligned between the two CE vendors that have provided PSP simulations in the past |
| R4-2002xxx(rev of R4-2002154) | Keysight Technologies UK Ltd | **Observation 1: The PSP simulations between the two CE vendors that have provided PSP simulations in the past are aligned****Observation 2: Beamforming assumptions are aligned between the two CE vendors that have provided PSP simulations in the past** |
| R4-2002155 | Keysight Technologies UK Ltd | Pending proposals |
| R4-2002xxx (rev of R4-2002155) | Keysight Technologies UK Ltd | **Observation 1: The 6 probes are spread in a sector of 48° in the azimuth domain and around 14° in the elevation domain.****Observation 2: The mean PSP% obtained for InO CDL-A is >87% for a system with range length of 1m.****Observation 3: The mean PSP% obtained for UMi CDL-C is > 89% for a system with range length of 1m****Proposal 1: For the NR FR2 MIMO OTA 3D MPAC system, utilize a total of 6 probes****Proposal 2: Adopt the 6-probe NR FR2 MIMO OTA 3D MPAC probe configuration tabulated in Table 1** |
| R4-2002157 | Keysight Technologies | Observation 1: For the reasonable measurement parameters required for the estimation, the corresponding measurement times could be large. Therefore, it is crucial to define suitable measurement parameters that are efficient in terms of time and the estimation accuracy is not compromised.Proposal 1: Further investigation is required for defining suitable measurement parameters. Feedback and proposals are welcomed. |

## Open issues summary

### Sub-topic 1-1 FR2 probes layout

**Issue 1-1-1: FR2 probes layout for 3D-MPAC**

* Proposals
	+ Option 1: 6 probes approach:
		- Proposal 1: Agree on 6 probes, 3 per scaled channel model, in FR2 MPAC MIMO OTA to be minimum number of probes.
		- Proposal 2: Use table 1 to place probe 1 in chamber for each channel model. Adjacent probes will be placed by optimizing the locations and weights.
		- Proposal 3: Adopt the table 2 probe locations with target PSP values.
	+ Option 2: 6 probes approach for each channel model:
		- Proposal 1: For the NR FR2 MIMO OTA 3D MPAC system, utilize a total of 6 probes
		- Proposal 2: Adopt the 6-probe NR FR2 MIMO OTA 3D MPAC probe configuration tabulated in Table 1
* Table 1: Proposed probe locations

|  |  |
| --- | --- |
| **Az [o]** | **El [o]** |
| -7 | 12 |
| -25 | 13 |
| -12 | 26 |
| -23 | 20 |
| -55 | 19 |
| -11 | 13 |

* Recommended WF
	+ TBA

**Issue 1-1-2: feasible SNR ranges for 3D MPAC**

* Proposals
	+ Option 1: The SNR upper bound for MIMO OTA with 8 probes is 33.4dB for 100MHz channel bandwidth.
	+ Option 2: The estimated maximum achievable SNR for the N probe system with the assumptions made in this contribution is ~20.9dB.
* Recommended WF
	+ TBA

**Issue 1-1-3: New proposed system for FR2 MIMO OTA**

* Proposals
	+ Proposal 1: Whether to utilize a DFF or IFF system is left up to the system implementation. Only the figure of merit and measurement uncertainty are defined.
	+ Proposal 2: Specific system implementation details like the antenna position and number of antennas are defined separately for each system type (DFF/IFF).
* Recommended WF
	+ New system without clear studied channel model generation, validation and test procedure, is not recommended at this stage

### Sub-topic 1-2 Calibration and validation

**Issue 1-2-1: calibration and test procedures**

* Proposals
	+ Proposal1: Check and refine text proposals in R4-2002151
	+ Proposal2: Check and refine text proposals in R4-2002074
* Recommended WF
	+ Update and finalize the calibration and test procedure, one revised TP is needed to capture agreeable content on calibration and test procedure.

**Issue 1-2-2: Channel model and Quality of Quiet Zone validation procedures**

* Proposals
	+ Option 1: Adopt the simplified two step validation technique to FR2 channel model validation. In R4-2002102
	+ Option 2: Joint Power-Angle-Delay validation approach for FR2. In R4-2002157
* Recommended WF
	+ Make decision on how to validate the channel models, and finalize the test proposals in the 2nd round.

**Issue 1-2-3: MU assessment**

* Proposals
	+ FR2 preliminary MU assessment in TP R4-2000896
* Recommended WF
	+ Update the MU assessment elements based on the Test Proposals in R4-2000896. Finalize the text proposals in the 2nd round.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Keysight | Sub topic 1-1: * Issue 1-1-1: We believe Spirent’s approach of selecting 6 probes (3 for CDL-C and 3 for CDL-C) can be further optimized. As outlined in the revised contribution of 2155, better performance can be achieved with a 6 configuration where all probes are used for each channel model. Additionally, technical concerns with the contribution 2073 will be outlined separately.
* Issue 1-1-2: As outlined in 2153 (late contribution), we believe the achievable SNR in 0505 is overestimated by setting the “Allowed noise increase dB” to 20 instead of 1 (compared to TR38.810). Additionally, the SNR increase of 9dB from 1 probe to 8 probes assumes omnidirectional UE antennas. An SNR increase of ~3.5dB (based on our simple assumption in 2153) for a multiprobe setup seems more realistic. At this point, we recommend highlighting the achievable SNR values for information and not include them in the TR38.827.
* Issue 1-1-3: MIMO OTA in the past did not consider FF conditions as an underlying requirement for MPAC systems; instead, the range length was determined based on the realization of channel models. This is different for the RTS method where the antenna pattern had to be measured in the far-field. In RAN4#90bis, it was decided "Number of probes and placement of probes for MPAC system for FR1 and FR2 have to be standardized in the MIMO OTA SI." per WF R4-1904160. It is therefore proposed to stick with this agreement to avoid different implementations resulting in different results.

Sub topic 1-2:* Issue 1-2-1:
* Issue 1-2-2: In Section 7.4.1.6 of 2102, it is proposed to perform the PSP validation based on rms spatial correlation error. It was previously agreed to use PSP instead of correlation error. While we can agree with the other additions, we cannot agree with Section 7.4.1.6.
* Issue 1-2-3:

Others: |
| Qualcomm | V1: Sub topic 1-1: * Issue 1-1-1: In option 1, the layout is derived under the assumption of 4\*4 UE antenna. If UE has other antenna configurations e.g., 4\*1 or 4\*2, will different antenna configurations lead to different layout? For both option 1 and option 2, is it possible to further optimize PSP with different configurations? Or lead to different probe layout?
* Issue: 1-1-2: The achievable SNR for single probe in paper R4-2002153 reuses the calculation from TR38810 which is under the assumption that artificial noise is transmitted from TE (to make sure SNR difference between reference point and baseband is less than 1dB). While in MIMO OTA, the noise-limited condition was agreed. Therefore, we need re-calculate the achievable SNR under the noise-limited condition. In our paper R4-2000505,20dB instead of 1dB is used to emulate the test condition that there is no artificial noise from TE. For the SNR gain due to the multi-probe, we agree 9dB is an ideal estimation. The actual gain would depend on channel model. We could capture the single probe achievable SNR and multi-probe gain range, e.g. 3.5-9dB in TR.
* Issue 1-1-3: A clarification question: Is it possible to introduce the alternative test system in WI phase considering this is proposed in this stage of SI?

Sub topic 1-2:* Issue 1-2-2: Why PSP is measured by Omnidirectional antenna? But other parameters (PDP, power, Doppler, XPR) is measured by directive antenna?

V2: Sub topic 1-1:* Issue 1-1-2:
	+ To Samsung:
		- It is a good point that non-peak direction might also be involved for MIMO OTA testing and it is related how to select the test direction(s) to derive the TRMS. We can further discuss SNR range after we decide the performance metric. Perhaps the estimated SNR range can be captured in TR for information.
 |
| MediaTek | **Issue 1-1-3: New proposed system for FR2 MIMO OTA**→ We support “Proposal 1” (#Whether to utilize a DFF or IFF system is left up to the system implementation. Only the figure of merit and measurement uncertainty are defined.) |
| MVG | Sub topic 1-1: * Issue 1-1-1:
* Issue 1-1-2:
* Issue 1-1-3: Agree with KS’s view. It was already agreed that an outcome of the SI must be to come up with a baseline system setup. Moreover, details of the system setup implementation must be provided in terms of number of probes, probes' locations, and range length. The latter was already agreed to be 0.75cm without considering any FF criteria. This issue seems to be conflicting with previous agreement

Sub topic 1-2:* Issue 1-2-1: block diagram in Figure 1 doesn't mention about any radio head. The latter will be needed to be connected to each probe element since CE and RCT are up to 6GHz. Further comments are below.
* Issue 1-2-2: Step 1 would imply using a directive antenna. Are there any requirements on the directive antenna in terms of directivity and half power beamwidth? We think the HPBW of the reference antenna should be at least the same as the sectors in azimuth and elevation where the probes are located.
* Issue 1-2-3: Row 5 -> CE uncertainty term related with absolute level, stability and linearity. Further comments are below.

V3Sub topic 1-1: * Issue 1-1-1: In R4-1904586, MVG did try to analyze the minimum distance between probes in terms of isolation. Our analysis was based on real probes used in the frequency range of 18-50GHz. The smallest distance between probes was 40mm which corresponds for a 0.75m range length to 3.27deg separation. If I am not mistaken in reading the table above, I do see even a 1deg separation between probes. If our interpretation is fine we do believe this would not be feasible to implement in lab
* Issue 1-1-2:
* Issue 1-1-3:

V4Sub topic 1-1: * Issue 1-1-1: after properly looking at the table above, MVG is in line with the adopted probe separation since it is in line with our recommendation as KS did already comment to Samsung. MVG comment in V3 for this issue can be ignored.
* Issue 1-1-2:
* Issue 1-1-3:
 |
| Samsung | Sub topic 1-1: * Issue 1-1-1:
	+ Since 3D scan is adopted in FR2 MIMO OTA, so the absolute placement of probe 1 is not so important but what more important is the relative position of other probes compared with probe 1. For proposal 3 of option 1, the distance between probe 1 and probe 2 for CDL-C Umi is so close about 4cm (considering 0.75m range length), I am not sure if 4cm distance is beyond the size of probe. Anyway, when optimizing probe locations, a minimum granularity in distance between probes shall be considered so that it shall not be closer than practical probe size.
	+ As agreed in R4-1904160, UE Antenna Pattern for channel model generation is isotropic, but not sure whether the figure of merit for PSP is based on isotropic UE antenna pattern or directional UE antenna pattern, could it be clarified? If PSP is based on directional UE antenna pattern, further study of UE antenna array assumption is necessary.
* Issue 1-1-2:
	+ It is good idea to capture SNR range calculation in TR. However, we observed that SNR range calculation is not applicable before performance metric is determined. Both option 1 and option 2, only beam peak direction is considered, it is not aligned with the MIMO OTA test scenario which is involved with non-peak direction test. The SNR range calculation at beam peak direction only works for beam peak direction test; for a 3D test, the SNR range calculation shall consider the worst case among all the test points except the exception points because the exception points will not be taken into account in performance metrics. Thus, SNR range calculation is applicable only after performance metric has been defined.
	+ Agree with QC that Noc shall not be considered when calculating SNR range since FR2 MIMO OTA is agreed to be noise-limited condition
	+ The multi-probe gain shall be calculated based on the final determined probe locations and weights rather than 10\*log10(N) etc. Except probe 1, the contribution of other probes is so small that it may be even ignored.
* Issue 1-1-3:

Sub topic 1-2:* Issue 1-2-1:
* Issue 1-2-2:
* Issue 1-2-3:

Others: |
| R&S | V1Sub topic 1-1:* Issue 1-1-1 (probe layout): 6 probes approach (3 per channel model) can be further optimized by rotating the channel model and consider a 3 probe configuration to cover both channel models.
* Issue 1-1-2 (SNR range): The 9dB gain assumption in R4-2000505 is a very best case where all probes transmit with the same power, but that is not realistic on a 3D MPAC approach. Achievable SNR depends on the number of probes and weighting for each of them, so it is system implementation dependent.
* Issue 1-1-3 (new proposed system): even though the proposal in R4-2002117 do not mention it, the system design with respect to channel model generation, validation and test procedure do not change from a DFF based to and IFF based system. Preliminary simulation results (to be shared when finalized) provide better PSP results with IFF based system compared to those presented in other contributions for the same test volume size due to the minimized amplitude and phase taper. Therefore, we propose to:
	+ Stick to previous agreements and agree on number of probes and placement for DFF based system, with the corresponding PSP target values
	+ Leave an open option to define the equivalent IFF based system that can achieve same or better PSP target values.

Sub-topic 1-2:* Issue 1-2-1 (cal and test procedure): since a 3D scan with [36] test points was agreed last meeting, a similar effect to what was considered in RF conformance might happen where the positioning guidelines using only P0 may negatively impact measurement results of DUTs with certain antenna placements. Therefore, the DUT alignment options described in TR 38.810 and TS 38.521-2 should be considered also here.
* Issue 1-2-2 (channel model and QoQZ validation):
	+ Option 1 according to R4-2002102 seems a more reasonable approach from complexity and test time point of view, but requires further refinement to provide information on how to relate the weighted rms correlation error to the PSP.
	+ Option 2 according to R4-2002157 has a major drawback related to the test time.
	+ Neither of both options provide enough details on the practical challenges related to FR2: measurement antenna, test on of both polarizations, etc.

V3Response to KS on Issue 1-1-3:* Due to operational issues before the meeting, we could not finalize the simulations and provide in a contribution format. The preliminary results mentioned before show a ~89% PSP for CDL-C with less probes than those proposed in KS’ R4-2002xxx (rev of R4-2002155), and therefore it will require less number of fading channels.

Response to KS on Issue 1-2-1: * On one hand, for the same device, and given the points are distributed evenly over the sphere, any metric based on the percentile should perform the same.
* On the other hand, and taking into account the arguments we considered in TR 38.810 to define the re-positioning approach, different devices may perform differently just because of the coupling or effects from the DUT holder to the specific antenna arrangement inside the device.
 |
| Keysight | Response to QC Issue 1-1-1: * 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. Arrays with more elements have a better resolution for sampling the PAS; therefore, the errors/simplifications of the model are observed with better accuracy. In turn, however, the PSP would be worse. Both CE vendors have used 4x4, array in simulations and these assumptions are used for system layout decisions only. Using a different antenna array assumption would not change the system layout since this layout, as proposed in our contribution, is only related to the ray directions.

Response to QC Issue 1-2-2:* The justification was provided in [R4-1915078] presented in the last meeting: “Measurement antenna: While a directive antenna can be used for this approach, it would require mechanical adjustments and thus prevent fully automated validation measurements. The measurement antenna should be isotropic in principle, in practice it is sufficient to have omni-directional pattern in azimuth and a wide beam width in elevation, e.g., bi-cone antennas, which would allow fully automated validation measurements. The estimation accuracy for the elevation domain might not be accurate, if the measurement antenna has a very narrow beam in the elevation domain.”

Response to MVG Issue 1-2-1: * Please see revised R4-2002151 with updated schematic system diagram

Response to Samsung Issue 1-1-1:* The KS simulations took into account MVG’s recommendation of 4cm min distance or 3.27deg probe to probe separation at 0.7m range length from R4-1904586.
* As outlined earlier, the PSP calculations should take into account directional antenna patterns for the system layout simulations for the Bartlett beamformer. This assumption is just used for the system layout simulations to finalize the probe configurations and for the channel model generation, the UE antenna assumptions are still isotropic.

Response to R&S Issue 1-1-1: * Just a rotation is not sufficient as the probe constellations per model are different. As shown in our earlier response above, a 3-probe configuration (non-rotated) shows relatively poor PSP performance and if a rotated, common 3-probe configuration was used, even worse PSP performance will be observed.

Response to R&S Issue 1-1-3:* We agreed to fix the system implementation between system vendors in terms of layout and number of probes on purpose. We even made sure that the channel model implementation aspects are aligned for NR (when compared to LTE to prevent the situation we had there).
* Allowing different system implementations with better performance will be very problematic. If that same argument was applied to FR1, KS could argue that an FR1 MPAC system with clustered, non-uniform probe spacing performs much better in terms of RMS spatial correlation performance and that it should be allowed. Of course the issue with this would be that some devices could perform completely differently in one system versus the other which is exactly what we wanted to avoid with the agreement in WF R4-1904160. Allowing different system implementations no longer levels the playing field.
* Since this meeting is supposed to be the final meeting of this SI with the intention to finalize the system layout for FR2 NR MIMO systems, a paper discussing such system with preliminary results would have been appreciated.

Response to R&S Issue 1-2-1:* Generally, we would be open to different alignment options. However, due to the very coarse nature of these test points, I would expect different alignment options to yield different performance. Shouldn’t we try to avoid this?

Response to R&S Issue 1-2-2:* We currently have just a single approach in Option 2 to base the channel model validation on PSP since Option 1 only checks for spatial correlation. While we agree that the approach in Option 2 shows test times of ~12hrs per frequency, the total validation time is certainly a lot more reasonable than for instance the FR2 QoQZ procedure which takes more than 1 week.

Does R&S have any recommendations in terms of alternate channel model validation procedures that are based on PSP? |
| CAICT | Sub topic 1-1:* Issue 1-1-1 (probe layout): for CDL-C UMi probe location, large gap is found between CE vendors: 3 for UMi or 6 for UMi. Encourage CE vendors to check each simulation and align on the optimized probe locations.
* Issue 1-1-2 (SNR range): SNR study is for checking the system testability to achieve the maximum throughput in each scenario. The SNR upper bound shall not be included in the TR. For system validation purpose, this example value can be fixed in the WI phase.
* Issue 1-1-3 (new proposed system): Any system that can provide the same performance with agreed 3D-MPAC is not precluded, this is something we are always expecting. However, considering this is the last meeting for NR MIMO OTA SI, without clear technical analysis or simulation we can not just agree IFF is in the SI scope to study. Encourage proponents to provide late contributions on this topic before the end of 1st round. Otherwise, any potential “new equivalent system” or potential “harmonized system” may be new scope in new SI or WI:
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### CRs/TPs comments collection

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

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| **CR/TP number** | **Comments collection** |
| R4-2000894 | Company A |
| Company B |
|  |
| R4-2000896 | MVG: Row 5 -> CE uncertainty term related with absolute level, stability and linearity CEs are designed with circuitry operating in the sub-6GHz band. In order for them to be used at mmWave, the so called radio head (up,and downconverter) must be added to each output before feeding the probe with a mmWave signal. Based on it, is the MU due to the radio head included in row5 uncertainty contributor? If it is the case, does it mean that on CE manufacturer datasheet the uncertainties related with the radio head are detailed? If CE data sheet would include radio head uncertainty, this must be specified in the description of the uncertainty term. |
| Company B |
|  |
| R4-2000897 | Keysight: * suggest to add InO in Section 3.3.

suggest to reword "The test zone size is 20cm for both FR1 and FR2 MIMO OTA testing" in Section A.4 to "The test zone size is 20cm for both FR1 and FR2 MIMO OTA testing for PC3 UEs; test zone sizes for other power classes are FFS." |
| SamsungAgree with Keysight that 20cm test zone size is applicable for PC3 for FR2. But for FR1, power class does not indicate UE type. Maybe just reword to "The test zone size is 20cm for both FR1 and FR2 MIMO OTA testing, larger test zone size is not precluded for further study"? |
|  |
| R4-2002074  | Keysight: We believe Spirent’s 6 probe locations can be further optimized, see revised contribution of 2155. We have some technical feedback on 2073 which is the baseline for 2074. Double checking the results in Figure 2 (single probe) showed some discrepancies in PSP simulations, especially in CDL-C. * InO CDL-A: KS simulations result in a PSP of 80.1% (Spirent: 81.61%)
* UMi CDL-C: KS simulations result in a PSP of 77.5% (Spirent: 84.03%).

Spirent’s proposed approach to calculate PSP in “totally in 7 positions in test volume, 6 on the boundaries and one in centre” is a good starting point but based on our experience, more points need be sampled within the volume and we would have expected the CDF curves with only 7 points to be more discrete. The CDL-A results in Figure 3 show worse performance for 8 probes which is unexpected. The max PSP values of ~98% in Figure 3 seem too high. Comparison PSP% results with the Spirent’s proposed 6 probe locations and the KS 6 probe locations with finer discretization of test points (same as outlined in revision of 2155) are shown below for CDL-Aand for CDL-C |
|  Qualcomm: The layout is derived under the assumption of 4\*4 UE antenna. If UE has other antenna configurations e.g., 4\*1 or 4\*2, will different configurations lead to different layout? Is it possible to further optimize PSP with different configurations? |
| Samsung:* + For proposal 3, the distance between probe 1 and probe 2 for CDL-C Umi is so close about 4cm (considering 0.75m range length), I am not sure if 4cm distance is beyond the size of probe. Anyway, when optimizing probe locations, a minimum granularity in distance between probes shall be considered so that it shall not be closer than practical probe size.
	+ Similar concern as Qualcomm. As agreed in R4-1904160, UE Antenna Pattern for channel model generation is isotropic, but not sure whether the figure of merit for PSP is based on isotropic UE antenna pattern or directional UE antenna pattern, could it be clarified? If PSP is based on directional UE antenna pattern, further study of UE antenna array assumption seems necessary.
 |
|  |
| R4-2002365 | Keysight: In Section 7.4.1.6 of 2102, it is proposed to perform the PSP validation based on rms spatial correlation error. It was previously agreed to use PSP instead of correlation error. While we can agree with the other additions, we cannot agree with Section 7.4.1.6 |
|  Qualcomm: Why PSP is measured by Omnidirectional antenna? But other parameters (PDP, power, Doppler, XPR) is measured by directive antenna? |
| MVG: Step 1 would imply using a directive antenna. Are there any requirements on the directive antenna in terms of directivity and half power beamwidth? We think the HPBW of the reference antenna should be at least the same as the sectors in azimuth and elevation where the probes are located. |
| R4-2002151 | MVG: block diagram in Figure 1 doesn't mention about any radio head. The latter will be needed to be connected to each probe element since CE and RCT are up to 6GHz. How to deal with that? Also in the calibration process there is no mention about radio head. Do this external HW need to be calibrated?For the TP procedure and mainly for the first step where setup must be verified. It looks like the lab would be required to verify channel environment any time before starting a TP vs Power measurement. Can you clarify on it? |
| R&S: V1As mentioned above, and since a full 3D test with [36] points was agreed in previous meeting, having only P0 as DUT position may negatively impact measurement results of DUTs with certain antenna placements. DUT alignment options described in TR 38.810 and TS 38.521-2 should be considered also here.In relation to Qualcomm’s comment to R4-2002152, we didn’t decide on the constant density implementation and how those [36] points are derived.Editorial comment, clause numbering seems to be wrong. 3D MPAC for FR2 is identified as 6.2.3, but subsequent clauses start with 6.2.1.x V3To KS response: Same argument as above. We firmly think that alignment options + re-positoning concept should be considered here to minimize the potential effect of test system holder on the performance for different UE with different antenna array panel implementations. |
| Keysight responses to MVG:* MVG: block diagram in Figure 1 doesn't mention about any radio head. The latter will be needed to be connected to each probe element since CE and RCT are up to 6GHz. How to deal with that?
	+ KS: I have added radio heads in the revised block diagram but pointed out that other implementations are not precluded.
* MVG: Also in the calibration process there is no mention about radio head. Do this external HW need to be calibrated?
	+ KS: The entire signal chain has to be part of the calibration regardless of system implementation.
* MVG: For the TP procedure and mainly for the first step where setup must be verified. It looks like the lab would be required to verify channel environment any time before starting a TP vs Power measurement. Can you clarify on it?
	+ KS: This language is taken from FR1 and I don’t see that there is really any difference FR1 vs FR2. As highlighted in Note 3, the channel models need to be validated at least once and maybe be necessary again if setup and instruments change.

Keysight responses to R&S:* Generally, we would be open to different alignment options. However, due to the very coarse nature of these test points, I would expect different alignment options to yield different performance. To prevent the possibilities of measured performance differences, it is suggested to fix the grid implementation, grid points, and default device alignment option.

The wrong section numbering was corrected in a revision; thanks for pointing this out. |
| R4-2002152 |  Qualcomm: With different constant density implementations, the test results might be different. Do we need to specify the implementation approach for constant density? |
| Keysight responses to QC: * while we “just” agreed to use a constant density scan approach, it is suggested to fix the grid points based on the charged particle implementation in R4-2002151. This grid implementation was shown to be the best for FR2 UE RF testing and should therefore be adopted here as well

As outlined earlier, 36 grid points is a very coarse grid and different implementations and relative orientations could lead to different results which should be avoided.  |
|  |

## 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*

|  |  |  |
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|  | **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*

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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 #2: FR2 performance metrics and channel model

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2000080 | Qualcomm Incorporated | Observation 1: The current static test mechanism cannot properly filter out UEs that do not proactively readjust their beams with a small delay.Proposal 1: A scenario where at least UE orientation is rotating over time during a test iteration should be considered for dynamic geometry-based MIMO OTA Testing. Other scenarios are FFS.Proposal 2: For UE orientation rotation-based tests, the following aspects will be discussed.* A common framework for RRM/RLM and/or Demod tests
* How to implement UE orientation rotation in 3D MPAC system
* How to define performance requirements
* Whether and how to cope with many different UE implementations especially in terms of beam pattern
 |
| R4-2000272 | Samsung | Observation 1: different spherical coverage percentile of different power classes, different UE form factors, and limitation of testability SNR range will lead to varying exception points quantity.Observation 2: exception points issue can be avoided by specifying the test points for TRMS calculation in a unified manner for all power classes.Proposal 1: define FR2 MIMO OTA performance metric as the averaging of the measured sensitivity at the test points within “MIMO OTA spherical coverage”, where the “MIMO OTA spherical coverage” means the spherical coverage in terms of MIMO OTA sensitivity rather than EIS. |
| R4-2000798 | MediaTek Beijing Inc. | Proposal1: Define fixed initial phase pattern(s) for sub-paths, for FR1 and FR2 respectively.Proposal2: Exact fixed initial phase pattern(s) is FFS, for FR1 and FR2 respectively. |
| R4-2000895 | CAICT | The sensitivity value at the [80th] percentile of the CCDF of the all the recorded data measured over the full sphere around UE is defined as the FR2 MIMO OTA requirement. |
| R4-2002069 | Spirent Communications | **Observation 1**: Thresholding of 30dB significantly reduces the number of taps to 1 tap in InO CDL-A, and three taps for UMi CDL-C.**Proposal 1**: Adopt an approximate 30 dB threshold to limit the number of Spatially filtered taps**Proposal 2 and 3:** Select improved DoT values of: InO CDL-A, DoT = 135 deg, UMi CDL-C, DoT = 100 deg, for use at all FR2 frequencies. |
| R4-2002364(rev of R4-2002069) | Spirent Communications | **Observation 1: Thresholding of 30dB significantly reduces the number of taps to 1 tap in InO CDL-A, and three taps for UMi CDL-C.****Proposal 1: Adopt an approximate 30 dB threshold to limit the number of Spatially filtered taps****Proposal 2 and 3: Select improved DoT values of: InO CDL-A, DoT = 112.51 deg, UMi CDL-C, DoT = 74.11 deg, for use at all FR2 frequencies.** |
| R4-2002070 | Spirent Communications | TP for DoT selection for FR2 channel model |
| R4-2002149 | Keysight Technologies UK Ltd | TP for Clarification of Beam Forming Weights |
| R4-2002150 | Keysight Technologies UK Ltd | Proposal 1: Keep the random initial phases as defined in [1] |
| R4-2002156 | Keysight Technologies UK Ltd | Observation 1: The number of spatial samples defined in wavelength becomes small as the test frequency decreases.Proposal 1: For the lowest four test frequencies, i.e., 617, 722, and 836.5 and 1575.42 MHz, adopt a spatial as λ/15 and λ/4 for first the quadrant of test zone circumference (270◦-180◦) and the remaining three quadrants, respectively.Proposal 2: For the highest five test frequencies, i.e., 1800, 2132.50, 2450, 3600 and 4700 MHz, adopt the spatial sampling as λ/10 and λ/2 for first quadrant of test zone circumference (270◦-180◦) and the remaining three quadrants, respectively, i.e., same as proposed in [2] |

## Open issues summary

### Sub-topic 2-1 Performance metrics

**Issue 2-1: Performance metrics**

* Proposals
	+ Option 1: define FR2 MIMO OTA performance metric as the averaging of the measured sensitivity at the test points within “MIMO OTA spherical coverage”, where the “MIMO OTA spherical coverage” means the spherical coverage in terms of MIMO OTA sensitivity rather than EIS.
	+ Option 2: The sensitivity value at the [80th] percentile of the CCDF of the all the recorded data measured over the full sphere around UE is defined as the FR2 MIMO OTA requirement.
* Recommended WF
	+ TBA

### Sub-topic 2-2 Channel models

**Issue 2-2-1: Direction of Travel**

* Proposal

The UE travelling direction (**v, **v) are as follows for FR2:

* (121.51°,90°) for InO CDL-A channel model
* (74.11°,90°) for UMi CDL-C channel model
* Recommended WF
	+ TBA

**Issue 2-2-2: initial phases for channel models**

* Proposals
	+ Option 1: Define fixed initial phase pattern(s) for sub-paths, for FR1 and FR2 respectively. Exact fixed initial phase pattern(s) is FFS
	+ Option 2: Keep the random initial phases as defined in [1]
* Recommended WF
	+ TBA

**Issue 2-2-3: Beam Forming Weights**

* Proposal
	+ Include the proposed changes to the channel model coefficient equations in TR38.827. in R4-2002149
* Recommended WF
	+ TBA

### Sub-topic 2-3 others

**Issue 2-3-1: spatial sampling points for FR1 spatial correlation validation**

* Proposals
* Proposal 1: For the lowest four test frequencies, i.e., 617, 722, and 836.5 and 1575.42 MHz, adopt a spatial as λ/15 and λ/4 for first the quadrant of test zone circumference (270◦-180◦) and the remaining three quadrants, respectively.
* Proposal 2: For the highest five test frequencies, i.e., 1800, 2132.50, 2450, 3600 and 4700 MHz, adopt the spatial sampling as λ/10 and λ/2 for first quadrant of test zone circumference (270◦-180◦) and the remaining three quadrants, respectively, i.e., same as proposed in [2]
* Recommended WF
	+ TBA

**Issue 2-3-2: FR2 dynamic testing**

* Proposals
* Proposal 1: A scenario where at least UE orientation is rotating over time during a test iteration should be considered for dynamic geometry-based MIMO OTA Testing. Other scenarios are FFS.
* Proposal 2: For UE orientation rotation-based tests, the following aspects will be discussed.
* A common framework for RRM/RLM and/or Demod tests
* How to implement UE orientation rotation in 3D MPAC system
* How to define performance requirements

Whether and how to cope with many different UE implementations especially in terms of beam pattern

* Recommended WF
	+ TBA

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Keysight | Sub topic 2-1: * Issue 2-1:
	+ Option 1: We believe all measurements and not just the N best should be considered for performance requirements
	+ Option 2: what is the technical justification for [80]%? Should we maybe align the percentage with EIS spherical coverage percentage? Is the same [80]% percentage suggested for all PCs?

Sub topic 2-2:* Issue 2-2-1: While we agree with the Text proposal, we have concerns with P1 from 2069: “Proposal 1: Adopt 30 dB threshold for CDL-A to limit the number of spatially filtered taps.” and cannot agree with this proposal as is.
* Issue 2-2-2: The carrier frequency of simulations in 798 is not mentioned and needs to be specified. For an assumed frequency of 3GHz, the number of fading conditions is approximately 1, 42, and 416 in the cases listed in the table 1. Among these, both 1 and 42 samples are evidently not sufficient and therefore show the very large PDP variance. With >400 samples, it is shown that the PDP variance is better. Simulation/measurement times for LTE MPAC OTA testing were discussed in R4-111381 and at minimum 1000 (or 100) wavelengths were recommended. In LTE the measurement time was 20s.

The channel models defined in TR 38.827 are fading channel models. Fading is modelled as a random process with certain statistical characteristics. These are actualized only with a sufficient number of samples of the process. The MTK contribution presents PDP variation between random seeds. How about computing PDP and other deviations from the specified statistics. Fixing the random seed would not help in this if the number of samples is very small, at least if not hand picked specifically for certain simulation lengths.* Issue 2-2-3:

Sub topic 2-3:* Issue 2-3-1:
* Issue 2-3-2: Keysight supports at least one scenario of dynamic geometry-based MIMO OTA Testing

Others: |
| Qualcomm | V1:Sub topic 2-1:* Issue 2-1: In general, compared with FR1, the rank condition and MIMO throughput in FR2 is highly related with test direction. Before we decide the performance metric, we might need to consider how many test points are valid to derive the performance which would impact TRMS requirements. We suggest to further decide the FR2 performance metric in WI phase with assist of test results or simulation results.
	+ For option 1, with top Nth percentage MIMO sensitivity, how many test points can satisfy the rank 2 test conditions and target MIMO throughput e.g. 70% or 90%? This would impact the selection through potions and the final TRMS requirements.
	+ For option 2, the target percentile, i.e. [80th] in TP, should be based on the power class. And similar comments as option 1. Without test results or simulation results, it is difficult to decide the performance metric. We suggest removing FR2 performance metric in TR and further discussing in WI phase.

Sub topic 2-2:* Issue 2-3-2: RAN4 should clarify if #94-e meeting is the last meeting for MIMO OTA SI. If yes, we should capture proposal 1 in TR so that proposal 2 can be further discussed.

V2:Sub topic 2-2:* Issue 2-3-2:
	+ To Samsung:
		- Our intention is to verify UE performance under dynamic scenario. UE rotation is equivalent to UE move around the BS. We don’t consider pathloss and AoD changing due to the high implementation complexity. Therefore, UE rotation is the simplest scenario for dynamic geometry testing.
	+ To R&S:
		- For Q1: In UE orientation rotation-based test, UE would not initiate the access for each test points and keep the connection during the test. While in static testing, UE needs initial access procedure and has enough dwell time in each test point.
		- For Q2: The channel mode is the same as static testing but just rotate UE during the testing. Yes, we need specify how to implement UE orientation rotation in 3D MPAC system which might include speed, acceleration, accuracy.
		- For Q3: We believe all UE performance aspects including RRM RLM and Demod should be studied under the dynamic geometry.
	+ To vivo:
		- We understand it is close to complete SI. However, dynamic geometry is one of objectives in this SI. We prefer to have some high level agreements in TR for future study if this is the only remaining issue after this meeting. How to proceed this dynamic geometry study should be a plenary topic.
 |
| MediaTek | **V1**Sub topic 2-1:* Issue 2-1: → We support Option 2. Compared to Option 1, we think Option 2 can mitigate the measurement uncertainty due to beam peak is captured or not, while the 3D scan test grid is [36] with constant density scanning.

Sub-topic 2-2:* Issue 2-2-2: → We support Option 1.

Sub-topic 2-3:* Issue 2-3-2: → Based on working model, we prefer to converge FR2 static testing issues firstly.

**V2**Sub-topic 2-2:* Issue 2-2-2:
	+ To Keysight and companies:
		- Thanks for Keysight’s comment and question. The selected carrier frequency is 4 GHz.
		- It’s fine for us if random initial phase of NR FR1 and FR2 is defined with certain conditions to mitigate the performance evaluation variation concern. How about to add a statement in TR38.827 to reflect it? For example, “For NR FR1 and FR2 MIMO OTA testing, measurement times shall larger than minimum [1000] or [100] wavelengths.”
		- If the proposed statement is okay to agree, companies are encouraged to share further study on exact measurement times. We will also do relative study.
 |
| Samsung | Sub topic 2-1: * Issue 2-1:
	+ Option 1: All the [36] test points will be measured, but not all the [36] measurement results are counted in the performance metric, because many test points can not reach even 70% throughput outage. A rule to preclude the exception points are necessary and “MIMO OTA spherical coverage” corresponding to the percentile of each power class is reasonable for performance metric.
	+ Option 2: Assume option 2 will count 80% of [36] test points in performance metric for PC3, there is achievable SNR range issue though. The upper limit of SNR range at 20%-tile (i.e. 80% of whole sphere) will be too low to achieve required throughput outage.

Sub topic 2-2:* Issue 2-2-1:
* Issue 2-2-2:
* Issue 2-2-3:

Sub topic 2-3:* Issue 2-3-1:
* Issue 2-3-2: Even static MIMO OTA test is facing challenging SNR condition, the situation will be even worse for dynamic geometry-based test. Moreover, UE rotation is not a typical user scenario, and it can not address the need of industry. We prefer to concentrate on the static MIMO OTA.

Others: |
| R&S | V1Sub topic 2-2:* Issue 2-2-3 (BF weights): corrections to equations 7.2-9 and 7.2-10 to add the *s* index for BS antenna and *me* and *ne* indexes for the antenna element offset are fine, but then some additional changes are missing. Further details below on the TPs comment section.

Sub topic 2-3:* Issue 2-3-2 (dynamic testing):
	+ Question for clarification: according to the observations and proposals in R4-2000080 it is not clear whether this proposal for “UE orientation rotation-based tests” is assuming to use the same static channel models, where only 1 TRxP or BS is considered.
	+ In case current BS assumptions and channel models in TR 38.827 are to be used as baseline for further discussion on dynamic testing, the requirements on DUT positioner specifications (speed, acceleration, accuracy, etc.) due to this “UE orientation rotation-based tests” might have a major impact on the overall system design.
	+ Except some RLM and BFD test cases, which are currently specified in multipath fading propagation conditions, all other test cases use AWGN channel condition. Is the intention of the proposal to address, in addition to the existing requirement, only these (RLM, BFD) test cases types in the NR FR2 MIMO OTA setup?

V3Sub topic 2-3:* To Qualcomm response on Issue 2-3-2:
	+ Additional requirements on the positioner specifications will then become much more relevant and may limit the test system implementations for NR FR2 MIMO OTA.
	+ Regarding the performance aspects, do you see this as a complement of current Rel.15 and 16 RRM/RLM and Demod test cases, or would it replace some of those?
 |
| vivo | Sub topic 2-3:* Issue 2-3-2 (dynamic testing): We are close to finish the SI. We think it is too late to start discussion of this complicated topic at this stage. Maybe a new R17 SI or extension to current FR2 test enhancement SI is more appropriate.
 |
| OPPO | Issue 2-1: Either option 1 or option 2 is ok if there is no testability issue.Issue 2-2-2: Prefer option 2 to avoid the possibility of inconsistent test results between labs or TEs. If there is difficulty in implementing this fixed initial phase, other solutions need to be considered.Issue 2-3-2: Prefer to complete static tests first. Dynamic tests can be discussed later. |
| CAICT | Sub topic 2-3:* Issue 2-3-2 (dynamic testing): suggest to focus on static testing scope.
 |

### CRs/TPs comments collection

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

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| --- | --- |
| **CR/TP number** | **Comments collection** |
| R4-2000895 | Qualcomm: See our comments in Issue 2-1. We suggest removing FR2 performance metric in TR and further discussing in WI phase |
| Samsung: It seems only applicable for PC3, there is achievable SNR range issue though. The upper limit of SNR range at 20%-tile (i.e. 80% of whole sphere) will be too low to achieve required throughput outage. It will be better to align test points for performance metric to the percentile of each power class, e.g., 50% test points for PC3. |
|  |
| R4-2002070 | Company A |
| Company B |
|  |
| R4-2002149 | R&S* Shouldn’t the *me* and *ne* indexes also be added to the NLOS equation (7.2-9) in the *dtx,s* term?
* On the NLOS equation (7.2-9), it also seems like *j* is missing on all the *exp(Φmxx)* terms in the matrix like shown in TR 38.901:

 |
| Keysight response to R&S * Yes, the *me* and *ne* indices need to be added to *d*tx,s term. This has been added in the draft revision

Yes, the *j* = sqrt(-1) is indeed missing and has been added in the revision as well. |
|  |

## 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** |
| #1 |  |  |

### 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*

|  |  |
| --- | --- |
| **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. R4-1916174, WF on FR2 MIMO OTA, CAICT, Spirent, RAN4#93, Nov. 2019
2. Meeting Report, RAN#86, Dec. 2019