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

**Electronic Meeting, November 2 – 13, 2020**

**Agenda item:** 13.1

**Source:** Moderator (Apple Inc.)

**Title:** Email discussion summary for [97e][331] FS\_FR2\_enhTestMethods

**Document for:** Information

# Introduction

*The email discussion on FS\_FR2\_enhTestMethods is organized into the following topics:*

* Topic #1: Test methodology for high DL power and low UL power test cases
* Topic #2: Solutions to minimize the impact of polarization basis mismatch between the TE and DUT on the RF testing
* Topic #3: Testability enhancements to support the verification of RF requirements for inter-band (FR2+FR2) CA
* Topic #4: Extreme temperature conditions for all applicable FR2 UE RF test cases
* Topic #5: Testability enhancements to support the verification of RF requirements for FR2 DL 256QAM
* Topic #6: Testability enhancements to reduce test time
* Topic #7: Testability aspects for the introduction of the new band n262
* Topic #8: Rapporteur input

We note that Topic #5 did not receive any contributions during this meeting.

# Topic #1: Test methodology for high DL power and low UL power test cases

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2014267](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014267.zip) | Qualcomm Incorporated | **Impact on beam management due to spherical wavefront in DL**  Observation 1: Impact of non-spherical WF of the DL reference signal requires further study before general conclusions can be drawn for all power classes, and all reasonable packaging variants for each power class. |
| [R4-2014919](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014919.zip) | Apple Inc. | **TP to TR38.884 on High DL and Low UL power test cases**  Proposal 1: It is proposed to approve the text proposal related to the high DL and low UL power test cases objective. |
| [R4-2015319](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2015319.zip) | CAICT | **Test methodology for high DL power and low UL power test cases**  Observation 1: The path loss is about 18dB lower than IFF/DFF method at the same range length 1.35m.  Observation 2: The path loss is about 3dB lower than traditional NF method at 0.22m range length. It means the measurement dynamic range and signal-to-noise ratio will be improved.  Observation 3: The method based on the coaxial cone TEM cell does not rely on the test antenna. It realizes the combination function of anechoic chamber and antenna.  Observation 4: The equivalent quiet zone is the area close to the outer conductor. Accordingly, the larger the cavity of the coaxial cone TEM cell, the larger the equivalent quiet zone.  Proposal 1: The method based on coaxial cone TEM cell could be used as one of the UE RF testing methods.  NOTE: late contribution |
| [R4-2016213](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016213.zip) | Keysight Technologies | **On Test methodology for high DL power and low UL power test cases**  Observation 1: White box testing generally requires the declaration by the manufacturer which antenna panel is active in any UL/DL test direction and the detailed locations of the panels within the DUT for full test case coverage  Observation 2: If white box test approach is selected for an enhanced NF test methodology supporting all conformance test cases, a vendor declaration is required which antenna panel is active in any UL/DL test direction and the detailed locations of the panels within the DUT.  Observation 3: If white box test approach is selected for an enhanced NF test methodology meant to provide full conformance test case coverage, x-y-z positioning systems to fully automate test cases will likely affect the Quality of QZ MU and increase test system complexity as well as test time.  Observation 4: If white box test approach is selected for an enhanced NF test methodology meant to provide coverage for the low UL/high DL power test cases only, a limited vendor declaration is needed, i.e., the phase centre offset of the panel yielding TX/RX beam peak radiation.  Observation 5: Feedback whether enhanced testability methods need to perform beam peak searches and spherical coverage tests was inconclusive.  Observation 6: For CATR test systems based on IFF test methodology white box vs black box testing makes little difference  Observation 7: For DFF and DNF systems, white box testing could eliminate the offset MU and potentially yield quality of quiet zone MUs for DFF and DNF based test systems similar to those of CATR based test systems  Observation 8: For white box testing, the min. range lengths for NF systems capable of single direction, TRP, and spherical coverage test cases is larger than for black box testing  Observation 9: The reduction in pathloss for NF systems is about 13dB (11dB) for black (white) box testing when compared to IFF.  Observation 10: The NF interface distances of 4x1 and 8x2 antenna arrays are in the FF of the single element.  Observation 11: The 50%-ile EIRP is approximated within ~1dB with the direct NF methodology  Observation 12: The EIRP beam peak (100%-ile EIRP) and direction cannot be measured accurately with the direct NF methodology.  Observation 13: Performing black-box DNF measurements with a UE and offset antennas in the known beam peak direction can yield incorrect EIRP/EIS measurements  Observation 14: Performing accurate black-box NF measurements with a UE and offset antennas requires local searches around the known beam peak direction to improve EIRP/EIS measurements.  Observation 15: When performing NF measurements of NR FR2 devices utilizing beam forming, the beam forming of the UE towards the NF measurement probe could result in measurements of undesired beams and incorrect EIRP/EIS beam peak measurements  Observation 16: Very large near-field path loss differences can be observed for NF testing methodology without any transform.  Observation 17: The novel NF testing approach with Transform shows very promising measurement accuracies for NF EIRP measurements utilizing the black-box approach  Observation 18: The novel NF testing approach with Transform can accurately predict the offset of the antenna array from the centre of QZ.  Observation 19: The black&white box approach (white: phase centre offset of active panel is declared; black: geometric centre of DUT is aligned with centre of QZ) does not require a FF probe to steer and lock the antenna beam towards the FF beam peak direction and has the same advantages as the black-box approach over the white-box approach.  Observation 20: The novel NF testing approach with Transform yields similar measurement accuracies for NF EIRP measurements utilizing the white&black-box approach when compared to the black-box approach  Observation 21: Large uncertainties can be observed for TRP for measurements performed in the NF utilizing the black back box approach.  Observation 22: With the offset of the antenna array known, e.g., estimated with the enhanced NF methodology introduced in this contribution, very accurate TRP measurements in the NF can be made with a TRP offset compensation approach  Proposal 1: Keep the black box test approach for NR FR2 conformance testing  Proposal 2: Adopt the effective antenna aperture approach, i.e., taking into account the frequency dependence of the max antenna array aperture, for NF range length determinations  Proposal 3: Do not consider the Direct NF methodology as enhanced methodology for conformance test cases.  Proposal 4: For black-box approach applied to NF measurements, NF systems to utilize a FF probe and UBF activation that allows the UE to select the intended beam.  Proposal 5: The NF testing methodology utilizing black-box approach without any transform cannot be considered for NR FR2 testing for EIRP/EIS based metrics.  Proposal 6: Feedback from industry is requested whether to continue efforts in terms of simulations and empirical investigations on this enhanced NF methodology with transform utilizing black-box approach  Proposal 7: Feedback from industry is requested whether to continue efforts in terms of simulations and empirical investigations on this enhanced NF methodology with transform utilizing the white&black-box approach  Proposal 8: Feedback from industry is requested whether the combination of black and white&black box approaches is acceptable to avoid the need for a vendor declaration.  Proposal 9: When performing TRP measurements in the NF, the offsets should be compensated to improve the measurement uncertainty. |
| [R4-2016377](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016377.zip) | MVG Industries, Sony | **Impact of phase variation**  Observation 1: At distances less than classical FF (ideal case) distance, the selected beams are different with respect to the FF case.  Observation 2: Figure of merits such as EIRP, TRP, and Spherical Coverage are not influenced dramatically from range length. This is valid in both static beam and dynamic beam scenarios |
| [R4-2016562](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016562.zip) | Rohde & Schwarz | **Views on test methods for high DL power and low UL power TCs**  Observation 1: Current permitted methods can be enhanced without any impact on test time or measurement uncertainty.  Observation 2: TRP measurements can be performed at Derat distance without impact on the MU.  Observation 3: FSPL improves by ~7dB for Direct Near Field measurements at Derat distance compared to IFF/DFF.  Observation 4: Displacement correction for TRP measurements based on manufacturer declaration will reduce MU for DNF systems.  Proposal 1: Non-permitted methods should be only considered if the improvement is better than the performance shown in table 3-1.  Proposal 2: Focus on the definition of DNF methodology based on Derat distance and the displacement correction based on manufacturer declaration. |

## Open issues summary

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

*NOTE:* [R4-2015319](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2015319.zip) *was submitted late, and the proposal is not included in the moderator summary. However, if consensus could be reached based on the proposal, then it could be included in the WF emerging from Round 1 discussions.*

### Sub-topic 1-1: Beam management sensitivity of NF based solutions

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 1-1-1: Simulation assumptions for beam management sensitivity of NF based solutions**

*Based on the agreed WF from the last meeting [R4-2012713], the agreed simulation assumptions can be captured in the following table:*

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Notes |
| Spherical coverage Measurement Grids baseline assumption | Annex G.1.1 in TR38.810 |  |
| Antenna array | 8x2 and 4x1 | Element near-field assumption is implementation specific |
| Simulated DUT | Two antenna arrays are integrated in the UE for the spherical coverage analyses  - Antenna panels are studied with Nz x Ny with Nz>Ny, e.g., 8x2 corresponds to Nz = 8 and Ny = 2  - The implementation loss for the antenna near the front is 0dB less than that for the antenna near the back  - The antenna in the back is on the opposite side of the UE (mirrored around (0,0,0)). | See Figure 5.1.2-1 for example positions of two antenna arrays |
| Beam steering | - In the xy plane, assume 45o beam steering granularity (AZ from -45o to +45o)  - In the xz plane, assume 22.5o beam steering granularity (EL from -90o to 90o) |  |
| Offsets | - Various antenna offsets (yoffset, zoffset) beyond 7.5cm in radius (12.5cm max) | Offset is defined with respect to the center of antenna array |
| Range Lengths | - 30cm, 20m (more range lengths are not precluded)  - Goal is to eventually determine min. range length and MU for performing spherical coverage tests in DNF | Defined as distance between centre of QZ/positioning axes and measurement probe |
| Test methodology | DNF (while taking path loss offsets into account) |  |
| Sampling grid | Study finer than 7.5deg step size for constant-step size grids | Parametric studies to show convergence for the selected assumption |

*The intention of this Issue is to collect company views on further improvements of the simulation assumptions*

* Proposal:
  + Alt 1-1-1-1: Include additional simulation assumptions according to [R4-2014267](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014267.zip):
    - Antenna element beams: Half power beam widths reduced from 260/130 to 90/90 (deg); Field was assumed to hold in array configuration in presence of other elements
    - Antenna array: 8x2 array, 3x5 beam positions; 2 equally competent arrays on opposite faces of a 6- sided box that is the UE
    - Field perturbation due to near field probe neglected; Field perturbation due to DUT fixturing neglected
  + Alt 1-1-1-2: Include the following simulation assumptions for TRP analysis according to [R4-2016213](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016213.zip):
    - Uniform distribution of offsets within the QZ; see contribution for histograms of each parameter, theta, phi, offset radius, x, y, and z.

**Issue 1-1-2: Results collection for beam management sensitivity of NF based solutions**

*Simulation results were provided in* [R4-2014267](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014267.zip)*,* [R4-2016213](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016213.zip)*, and* [R4-2016377](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016377.zip)*. The intention is to summarize the available results during the meeting. Preliminary tables are proposed below, and feedback on the table format (i.e. which metrics are useful to summarize) as well as the data is requested.*

*The table below summarizes the results from simulations of beam management sensitivity of DNF (i.e. beam peak search is performed in the NF)*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Company and reference | Swept parameters | Beam management performance maximum ∆ relative to reference (dB) | | | Notes |
| Beam peak | 50% CDF | TRP |
| Company A [R4-2014267] | Array: 8x2  Range: {0.2, 0.4, 0.8} m  Offset: {0, 0.05, 0.10} m | [0] ?? | FFS | Not analyzed | For PC3 UEs, there seems to only be mild perturbation of the spherical coverage CDF despite the dire beam choice predictions made in the study. This aspect needs to be studied further, as well as how to resolve for other power classes |
| Company B [R4-2016213] | Array: 8x2, 4x1  Range: {0.25, 0.3, 0.45, 20} m  Offset: {0.125 in y, 0.125 in z, 0.09 in y & z} m | 7.0 | 1.0 | TRP analyzed separately | The EIRP beam peak (100%-ile EIRP) and direction cannot be measured accurately with the direct NF methodology |
| Company B [R4-2016213] | Array: 8x2  Range: 0.2 m  Offset: 0.15 m in x, y, z |  |  | 0.66 dB systematic  0.46 dB RSS’ed | Large uncertainties can be observed for TRP for measurements performed in the NF utilizing the black back box approach |
| Company C [R4-2016377] | Array: 4x1  Range: {100, 4.2, 0.9, 0.45, 0.3} m  Offsets: not specified | 0.3 | [0] ?? | 0.1 | Figure of merits such as EIRP, TRP, and Spherical Coverage are not influenced dramatically from range length |

*The table below summarizes the results from simulations of beam management sensitivity of NF (i.e. beam peak search is first performed in the FF/IFF and test case is executed in the NF)*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Company and reference | Swept parameters | Beam management performance maximum ∆ relative to reference (dB) | | | Notes |
| Beam peak | 50% CDF | TRP |
| Company B [R4-2016213] (“Black box with transform approach”) | Array: 8x2, 4x1  Range: {0.22 – 0.30} m  Offset: {0, 0.50, 0.10, 0.125} m | Max µ = 0.2  Max σ = 0.3  Worst case with 99% confidence: 1.1 | Not analyzed | Not analyzed | Feedback from industry is requested whether to continue efforts in terms of simulations and empirical investigations on this enhanced NF methodology with transform utilizing black-box approach |
| Company B [R4-2016213] (“White box with transform approach”) | Array: 8x2, 4x1  Range: {0.22 – 0.30} m  Offset: {0, 0.50, 0.10, 0.125} m | Max µ = [0.1] ??  Max σ = [0.3] ??  Worst case with 99% confidence: 1.0 | Not analyzed | TRP analyzed separately | Feedback from industry is requested whether to continue efforts in terms of simulations and empirical investigations on this enhanced NF methodology with transform utilizing the white&black-box approach |
| Company B [R4-2016213] (“TRP with compensation for antenna offset”) | Array: 8x2  Range: 0.2 m  Offset: 0.15 m in x, y, z |  |  | 0.02 dB systematic  0.21 dB RSS’ed | With the offset of the antenna array known, e.g., estimated with the enhanced NF methodology introduced in this contribution, very accurate TRP measurements in the NF can be made with a TRP offset compensation approach |
| Company C [R4-2016377] | Array: 4x1  Range: {100, 4.2, 0.9, 0.45, 0.3} m  Offsets: not specified | 0.3 | [1.0] ?? | 0.8 | Figure of merits such as EIRP, TRP, and Spherical Coverage are not influenced dramatically from range length |

*The intention of this Issue is to collect company results available so far and to stabilize the format of the table so that additional results can be provided in the next meeting.*

* Proposal: Companies are encouraged to provide feedback on the table format, values in the table, and to share any other results that might have been missed in the summary

### Sub-topic 1-2: NF based solutions and test setup descriptions

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 1-2-1: Which NF based solutions are in scope of the SI?**

* Proposals
  + Alt 1-2-1-1: Direct near-field (DNF)
  + Alt 1-2-1-2: Near-field with assistance (NFA) of beam peak search in an FF/IFF system
  + Alt 1-2-1-3: Others?
* Recommended WF
  + It is recommended to finalize the list of applicable NF based solutions in order to enable the collection of test method setup descriptions for the next RAN4 meeting

**Issue 1-2-2: For NF based solutions what manufacturer declarations should be considered in scope of the SI?**

* Proposals
  + Alt 1-2-1-1: Only as agreed in WF [R4-2012713, slide #4]
  + Alt 1-2-1-2: Additional declarations are needed (companies are encouraged to identify these in their comments)

### Sub-topic 1-3: Enhancement of permitted methods

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 1-3-1: Summary of potential improvements of permitted methods**

*Based on the analysis provided in* [R4-2016562](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016562.zip)*, a preliminary table of potential improvement of permitted methods is provided below. The intention of this Issue is to collect company views on the feasibility of the proposed potential improvements of permitted methods.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Case** | **Test Metric** | **Regulatory related** | **TS 38.521-2 Test Requirements** | **Potential improvement** |
| 7.4 Maximum input level | EIS | No | 26dB relaxation for 24.25 ~ 29.5 GHz and 34 dB relaxation for 37 ~ 40 GHz with respect to minimun requirements. | ~ 6dB for FR2a  ~10dB for FR2b |
| 7.5 Adjacent channel selectivity | EIS | Yes, for case 1. | Added relaxations for ACS Case 1:   * 50MHz: 1.8dB relaxation for power in transmission BW and interferer for band n260. * 100MHz: 4.8dB relaxation for power in transmission BW and interferer for band n260. * 200MHz and 400MHz are deemed not testable.   Decision not test ACS case 2. | Similar improvements as for TC 7.4  All single carrier bandwidth could be testable 400 MHz, without relaxations up to 200 MHz |
| 6.3.2 Transmit OFF power | TRP | Yes | Relaxations for n257: 21.4dB @ 50MHz, 24.4dB @ 100MHz, 27.4dB @ 200MHz and 30.4dB @ 400MHz.  Relaxations for other bands are still TBD. | ~ 10dB for FR2a and FR2b |
| 6.5.2.3 Adjacent channel leakage ratio | EIRP | Yes | Relaxation for n257, n258 and n261: 0dB, except for 200Mhz (0.5dB in one test ID) and 400MHz (between 1.5 and 3.5dB) | Improvements remove required relaxations from TC |
| 6.3.1 Minimum output power | EIRP | No | No relaxation for PC1. For other power classes, relaxation varies from 0dB to 13.5dB depending on the operating band and channel bandwidth. | ~ 10dB for FR2a and FR2b  FR2a requirements testable without relaxations |

* Proposal: Companies are encouraged to provide feedback on the table format, values in the table, and to share any other results that might have been missed in the summary

**Issue 1-3-2: Criteria for consideration of non-permitted methods**

* Proposal: For a given test case, non-permitted methods should be only considered if the improvement is better than the potential improvement of the permitted method.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Issue** | **Company Comments** |
| Issue 1-1-1: Simulation assumptions for beam management sensitivity of NF based solutions | MVG: Based on the simulation results from R4-2014267, R4-2016213, and R4-2016377, we can clearly say the results are DUT dependent. DUT’s beams patterns are affecting the simulation results. Specifically, we ran some further simulation to compare the figure of merits when considering FS arrays and arrays on a phone size ground plane. New results are reported under issue 1-1-2 as a comment to KS contribution R4-2016213. |
| Issue 1-1-2: Results collection for beam management sensitivity of NF based solutions | MVG: Comment to KS contribution R4-2016213.  We have been trying to address some of the difference seen between our results and KS’s ones. Specifically, we focused on the 4x1 linear array. In our simulation a full phone model (including the PCB and phone house) has been considered. This is in line with the simulation setup for UE spherical coverage discussion in FR2 (38.101-2). In order to see whether the simulation results are affected by the DUT beams patterns, we also simulated two FS arrays with using the same y and z offset. EIRP peak error and CDF curves have been then compared for the two scenarios. Here is a summary of our results:    Differences can be observed between Ground plane and FS. Our FS results are in better agreement with KS. It looks KS is simulating a FS arrays. Here is also a CDF curves comparison:  Chart, line chart  Description automatically generated  Due to the fact EIRP max error is seen in the direction of the beam, we ran some simulations to understand the direction of the beam for the arrays simulated by KS and MVG. Results are also reported in summary table above. Looking at those results can be observed that for the MVG case (Free space) the error is worse for z-offset than y-offset because the antenna has a narrower pattern in elevation while KS sees higher error with the y-offset. However. MVG and KS results with z-offset compares better than the y-offset.  On the other hand, we were observing good agreement between our simulation results (R4-2016377) and simulation results in R4-2014267). Both beam selection error study and spherical coverage curves at different distances seem to be consistent between the two contributions. |
| Issue 1-2-1: Which NF based solutions are in scope of the SI? | MVG: Only support Alt 1-2-1-1: Direct near-field (DNF). We have to be careful with regard to Alt 1-2-1-2. Basically, this is a new setup where we do introduce a NF probe in a well-defined geometry of the CATR. Is the NF probe in when doing beam search? CATR is not so flexible as a testing solution. Its performances are determined essentially by the geometry (optic) of the setup. What is the sensitivity of the CATR performances w.r.t the NF probe? |
| Issue 1-2-2: For NF based solutions what manufacturer declarations should be considered in scope of the SI? |  |
| Issue 1-3-1: Summary of potential improvements of permitted methods | Anritsu: We need more time to review if we will be able to obtain a similar performance with the reported values in R4-2016562. |
| Issue 1-3-2: Criteria for consideration of non-permitted methods |  |

### 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** |
| [R4-2014919](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014919.zip) |  |
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## 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: Solutions to minimize the impact of polarization basis mismatch between the TE and DUT on the RF testing

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2014266](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014266.zip) | Qualcomm Incorporated | **FR2 testability enhancement for polarization mismatch**  Observation 1: TPMI side condition method (option 1 in WF R4-2012714) to enhance UE EIRP measurement has been adopted by the standard.  Observation 2: The DL pol. scan method (option 2 in WF R4-2012714) is not a valid method to enhance UE EIRP measurement.  Observation 3: In addition to enhancing TE with dual pol coherent receivers, dual TE transmitter chains to support 2-layer CSIRS may be a future enhancement avenue to optimize the UEâ€™s beam choice. |
| [R4-2014725](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014725.zip) | Samsung | **Discussion on FR2 EIRP measurement enhancement**  Observation 1: TPMI side condition method is only applicable for EIRP measurement of UL MIMO operation including â€˜full power transmissionâ€™  Observation 2: TPMI side condition method is only applicable for partial Rel-16 and beyond UEs  Observation 3: TPMI is controlling logical antenna ports rather than physical antenna ports  Observation 4: DL polarization scan method is applicable for non-codebook based transmission which is seldom used in RAN4 and RAN5 test cases.  Observation 5: DL polarization scan method depends on special UE implementation and does not eliminate polarization mismatch between TE and UE.  Observation 6: DL polarization scan method increase test time by N times which conflicts with the test time reduction objective, and not practical since the battery does not support so long time test.  Observation 7: it is normal and useful tool to adopt test mode in RF measurement.  Proposal 1: TPMI side condition method is only applicable for EIRP measurement for UL MIMO operation for partial UEs. Other methods to enhance EIRP measurement need to be investigated for non-MIMO cases in clause 6.2 of TS 38.101-2.  Proposal 2: Codebook based transmission shall be adopted in EIRP measurement, and DL polarization scan is not suitable  Proposal 3: Test mode to trigger TX diversity shall be adopted in EIRP measurement for non-MIMO cases (i.e. clause 6.2 rather than 6.2D of TS38.101-2). |
| [R4-2014827](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014827.zip) | MediaTek Inc. | **Analysis on practical TPMI and 2-port CSI-RS for EIRP measurement**  Observation 1: Apply TPMI is the typical case for Rel-15 and forward UE.  Observation 2: Two-antenna-ports TPMI cases are defined for Rel-15 and forward UE.  Observation 3: The available TPMI while “transform precoder is enabled” is defined in TS 38.212. For example, while UE support “meet fullyAndPartialAndNonCoherent”, TPMI 0~5 can be used. Hence, practical TPMI can be used to enhance UE performance in real filed.  Observation 4: EIRP measurement result based on 1-port CSI-RS is not enough to reflect real UE achievable EIRP performance in real field.  Proposal 1: List and apply “TPMI side condition method” as one of EIRP measurement enhancement methods for Rel-15 and forward UE.  Proposal 2:”Practical TPM” shall be further applied for “TPMI side condition method”  Proposal 3: “2-port CSI-RS” shall be provided in EIRP test procedure.  Proposal 4: “2-port CSI-RS” can be provided simultaneously or in sequent. |
| [R4-2014920](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014920.zip) | Apple Inc. | **Views on polarization mismatch**  Proposal 1: It is proposed to remove Option 3 (test mode to trigger TX diversity) from the list of candidate solutions for the EIRP measurement enhancement part of the polarization mismatch objective.  Proposal 2: It is proposed to confirm the dual polarization coherent receivers measurement setup as the enhancement which addresses the UE demodulation part of the polarization mismatch objective. |
| [R4-2015871](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2015871.zip) | Sony, Ericsson | **Views on testability enhancement for UE FR2 test**  Observation 1: There is no conflict between core requirement and EIRP test.  Observation 2: The current test method can capture the UE transmitted power correctly, and how a UE uses one or more Tx chains to transmit is an implementation issue.  Observation 3: The mapping between digital ports and RF ports can be flexible in the implementation.  Observation 4: The codebook-based transmission is typically used when the uplink/downlink reciprocity does not hold, which may be against the principle of beam correspondence test.  Observation 5: The power command has been adopted in the RF test to ensure the UE reaches its maximum output power.  Observation 6: Power command is the only mechanism that the network can use to control the UE output power in real life.  Proposal 1: The current EIRP test is feasible to be applied to different UE RF implementations and shall be kept without any modification  Proposal 2: Any potential command or setting for the EIRP test enhancement shall be avoided. The Test Equipment shall use the same signaling/commands to the UE as a real deployed network would.  Proposal 3: Devices that do not support Tx diversity in the field shall not be triggered with Tx diversity in the EIRP test.  Proposal 4: A UE cannot transmit with Tx diversity with power command should been seen as an ill-behaved devices and should not be accommodated by modifying the test procedure.  Proposal 5: Test enhancement for EIRP shall focus on the power command as it is the only command that the network can use to control the UE output power in the field. |
| [R4-2016212](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016212.zip) | Keysight Technologies | **On minimizing the impact of polarization basis mismatch between the TE and DUT**  Observation 1: For coherent UEs, both Rel-15 and Rel-16 allow a TPMI to be used that forces single-layer transmission using two antenna ports.  Observation 2: For non-coherent UEs, Rel-15 does not allow a TPMI to be used that forces single-layer transmission using two antenna ports.  Observation 3: For non-coherent UEs, Rel-16 allows a TPMI to be used that forces single-layer transmission using two antenna ports with the newly introduced ul-FullPowerTransmission = fullpowerMode1 mode.  Observation 4: : A polarization scan with N different scans requires the EIRP based test times to increase approximately by a factor or N  Observation 5: The polarization scan with linear polarizations can capture the TX diversity gain when the single DL polarization triggers both UE polarizations transmitted in UL  Observation 6: Whether there is a difference between test and field with the polarization scan should be irrelevant as long as this methodology can reliably capture the diversity gain.  Observation 7: A test mode would reliably trigger both polarizations in the UL with almost no increase in test time.  Observation 8: A test mode would require non-standardized implementations and some additional overhead by OEMs to support and maintain the test modes.  Observation 9: Whether there is a difference between test and field with the test mode should be irrelevant as long as this methodology can reliably capture the diversity gain  Proposal 1: Clarification is needed whether RAN1â€™s definition of TPMI indices 2-5 forcing single-layer transmission using two antenna ports corresponds to the UE enabling two transmit chains at all times  Proposal 2: Given the limited applicability of the TPMI approach and the uncertainty whether transmission using two antenna ports corresponds to enabling both transmit chains, it is proposed to focus on the alternative approaches instead.  Proposal 3: OEMs to provide feedback on the minimum number of required polarization scans to guarantee the diversity gain to be captured reliably.  Proposal 4: Clarification of the differences in behaviour between the field and the current measurement methodologies is needed.  Proposal 5: RAN4 to further consider the polarization scan which can reliably force the UE to simultaneously transmit on both transmit chain/antennas in order to minimize the impact of polarization basis mismatch between the TE and DUT.  Proposal 6: RAN4 to further consider the test mode to trigger both polarizations in UL if OEMs are willing to support these efforts. |
| [R4-2016568](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016568.zip) | Rohde & Schwarz | **Views on polarization basis mismatch**  Observation []: Test mode to trigger Tx Diversity is the most consistent and reliable option to ensure a two port transmission in all cases.  Proposal 1: DL polarization scan method shall not be considered as an option.  Proposal 2: Chipset and OEM manufacturers to confirm whether Rel-15 nonCoherent UEâ€™s and Rel-16 nonCoherent without full power transmission mode1 (ul-FullPowerTransmission = fullpowerMode2 or fullpower) are still affected by this DL polarization mismatch issue.  Proposal 3: Chipset and OEM manufacturers to confirm whether CSI-RS transmitted simultaneously over the two polarizations of the test antenna is enough to trigger the UE to transmit over two ports.  Proposal 4: Chipset and OEM manufacturers to confirm whether a two-layer DL transmitted over polarization diversity from the test antenna will trigger the UE to transmit over two ports.  Proposal 5: select the method based on manufacturer declaration:  a. If UE declares codebookSubset = fullyAndPartialAndNonCoherent, TPMI index is set to [2]. This is applicable to UE’s from Rel.15 onwards.  b. If UE declares codebookSubset = nonCoherent and ul-FullPowerTransmission-r16 = fullpowerMode1, TPMI index is set to [2]. This is applicable to UE’s from Rel.16 onwards.  c. Otherwise, an alternate method TBC is to be used (e.g. 2-port CSI-RS, test mode or other). |

## Open issues summary

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

### Sub-topic 2-1: EIRP measurement

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 2-1-1: TPMI side condition method**

* Proposals
  + Alt 2-1-1-1a: TPMI side condition method (option 1 in WF R4-2012714) to enhance UE EIRP measurement has been adopted by the standard, and the testability enhancement “TPMI side condition method” can be considered adopted
  + Alt 2-1-1-1b: Alt 2-1-1-1a with further clarification that “Practical TPMI” shall be further applied for “TPMI side condition method”
  + Alt 2-1-1-1c: Alt 2-1-1-1a only if clarification is provided whether RAN1’s definition of TPMI indices 2-5 forcing single-layer transmission using two antenna ports corresponds to the UE enabling two transmit chains at all times
  + Alt 2-1-1-1d: Alt 2-1-1-1a only if chipset and OEM manufacturers can confirm whether Rel-15 nonCoherent UE’s and Rel-16 nonCoherent without full power transmission mode1 (ul-FullPowerTransmission = fullpowerMode2 or fullpower) are still affected by this DL polarization mismatch issue.
  + Alt 2-1-1-2: TPMI side condition method is only applicable for EIRP measurement for UL MIMO operation for partial UEs. Other methods to enhance EIRP measurement need to be investigated for non-MIMO cases in clause 6.2 of TS 38.101-2

**Issue 2-1-2: Configuration of 2-port CSI-RS**

* Proposal: “2-port CSI-RS” shall be provided in EIRP test procedure; it can be provided simultaneously or sequentially

**Issue 2-1-3: Test mode to trigger TX diversity**

* Proposals
  + Alt 2-1-3-1: Remove test mode to trigger TX diversity (Option 3 in WF R4-2012714) from the list of candidate solutions for the EIRP measurement enhancement part of the polarization mismatch objective
  + Alt 2-1-3-2: Test mode to trigger Tx Diversity is the most consistent and reliable option to ensure a two port transmission in all cases

**Issue 2-1-4: Applicability of TPMI, 2-port CSI-RS, and test mode solutions**

* Proposal: select the method based on manufacturer declaration:
  + a. If UE declares codebookSubset = fullyAndPartialAndNonCoherent, TPMI index is set to [2]. This is applicable to UE’s from Rel.15 onwards.
  + b. If UE declares codebookSubset = nonCoherent and ul-FullPowerTransmission-r16 = fullpowerMode1, TPMI index is set to [2]. This is applicable to UE’s from Rel.16 onwards.
  + c. Otherwise, an alternate method TBC is to be used (e.g. 2-port CSI-RS, test mode or other).

**Issue 2-1-5: DL polarization scan method**

* Proposals
  + Alt 2-1-5-1: The DL pol. scan method (option 2 in WF R4-2012714) is not a valid method to enhance UE EIRP measurement
  + Alt 2-1-5-2: RAN4 to further consider the polarization scan which can reliably force the UE to simultaneously transmit on both transmit chain/antennas in order to minimize the impact of polarization basis mismatch between the TE and DUT with the following clarifications:
    - OEMs to provide feedback on the minimum number of required polarization scans to guarantee the diversity gain to be captured reliably
    - Clarification of the differences in behaviour between the field and the current measurement methodologies is needed

**Issue 2-1-6: Power up command to trigger TX diversity**

* Proposal: Test enhancement for EIRP shall focus on the power command as it is the only command that the network can use to control the UE output power in the field

### Sub-topic 2-2: UL demodulation

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 2-2-1: Dual polarization coherent receivers**

* Proposal: It is proposed to confirm the dual polarization coherent receivers measurement setup as the enhancement which addresses the UE demodulation part of the polarization mismatch objective

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Issue** | **Company Comments** |
| Issue 2-1-1: TPMI side condition method |  |
| Issue 2-1-2: Configuration of 2-port CSI-RS |  |
| Issue 2-1-3: Test mode to trigger TX diversity | Anritsu: We are hesitant to support alt 2-1-3-2, but it might still be one of the compromises if we consider it can also be a solution for another topic of transparent Tx diversity measurement procedure. |
| Issue 2-1-4: Applicability of TPMI, 2-port CSI-RS, and test mode solutions |  |
| Issue 2-1-5: DL polarization scan method | Anritsu: Support 2-1-5-1. We suppose the procedure to align the DL polarization is not what a user does in the actual field. |
| Issue 2-1-6: Power up command to trigger TX diversity |  |
| Issue 2-2-1: Dual polarization coherent receivers |  |

### 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.*

|  |  |
| --- | --- |
|  | **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”* |

# Topic #3: Testability enhancements to support the verification of RF requirements for inter-band (FR2+FR2) CA

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2014265](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014265.zip) | Qualcomm Incorporated | **On impact of non-co-located test antennae for FR2 inter-band testing**  Observation 1: The propagation loss between the QZ and a TE antenna located at the focus of an offset parabolic mirror is not uniform across the QZ.  Observation 2: Off-focus TE antenna causes beam tilt and a change in QZ illumination pattern in an IFF system.  Observation 3: In an IFF system, there is a one-to-one relationship between beam tilt at QZ and the angular offset between source and focus.  Observation 4: Effective QZ size reduces when considering beams from multiple non-co-located sources in an IFF system  Observation 5: Non-co-located sources in an IFF system can trigger different choice of optimum UE beam facing each source  Observation 6: IFF systems with non-co-located sources can benefit from â€˜white/grey boxâ€™ discussion that is broken down by power class. PC1 and PC5 may have a different optimum than PC3.  Observation 7: An IFF test set up with multiple test antennae is feasible for inter-band CA testing of UEs with IBM, but additional considerations must be made, like system calibration procedures, and QZ size characterization.  Observation 8: An IFF test set up with multiple test antennae is feasible for inter-band CA testing of UEs with CBM limitation, but only for band combinations that share the same TE antenna. |
| [R4-2014492](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014492.zip) | Fraunhofer HHI, Fraunhofer IIS | **Beam correspondence performance measurement improvements of FR2 UEs that use carrier aggregation and shared antenna arrays**  Observation 1: In common beam management and when using a shared antenna array and beamformer together with aggregated component carriers (i.e., in carrier aggregation), beam squinting effects and EIRP differences in the uplink can create link performance imbalances.  Observation 2: In CBM, the PCC is used as the reference for beam management and beam correspondence related decisions.  Observation 3: In CBM, the lead component carrier used for beam management and/or beam correspondence purposes should be dynamically chosen between the component carriers assigned to PCC and SCC. Choices should match scheduling decisions made in connection with load balancing and the trade-off of aggregated link performance versus individual link performance.  Observation 4: Existing RRC signalling mechanisms used to change the CC assigned to PCC on a gNB are considered ineffectively slow since it is necessary to rapidly change the lead component carrier used for beam management and/or beam correspondence purposes.  Proposal 1: Measurement procedures of beam correspondence with CA in FR2 should be the subject of further investigation.  Proposal 2: A liaison station should be sent from RAN4 to both RAN1 and RAN2. The LS shall:  • inform and explain the need for enhanced mechanisms that allow for quickly changing the lead component carrier used for beam management and/or beam correspondence for CA in FR2;  • request further study of the identified gap in current framework; and  • consider performance enhancement procedures within CA framework for UEs with shared antenna arrays across all frequencies associated with any particular CC combination in FR2. |
| [R4-2014687](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014687.zip) | Anritsu Corporation | **Testability of FR2 inter-band DL 2CA EIS by non co-located antenna**  Observation 1: A difference of path loss between the main antenna and non co-located antenna (100 mm shift) is 0.07 dB maximum at the range length 800 mm and does not have a significant impact on the DPSD of DL signal in FR2.  Observation 2: Single carrier Rx beam profiles which are measured by the main antenna and the offset antenna can be assumed identical as far as the two calibrated measurement antennas are arranged along with the q rotation of the positioner.  Observation 3: As far as the UE is supporting the IBM and both main antenna and offset antenna are arranged along with the q rotation of the positioner, it is possible to obtain the identical EIS results from either of the two antennas even with the inter-band CA tests.  Observation 4: A post processing to adjust the coordinates of the beam profile is necessary for data obtained by the offset antenna.  Observation 5: Comparing the measured result with the main antenna, a mean error by measuring from the offset antenna (4 degrees angular offset) increased slightly with both non-TTD and TTD type phase shift (0.085 dB increase with non-TTD and 0.116 dB increase with TTD at 43.5 GHz.) which are applied to the CBM UE.  Observation 6: For the standard deviation, only the result with TTD phase shifter showed the slight increase of measurement uncertainty (0.057 dB at 43.5 GHz.).  Observation 7: For both mean error (systematic error) and standard deviation (random error) with the offset antenna (4 degrees angular offset), these uncertainty values are within the acceptable level even with the UE supporting CBM (1x4 elements).  Observation 8: FFS for UEs which supports wider frequencies (such as n262 in addition) or higher power such as PC1.  Observation []: As far as the UE is supporting the IBM and both main antenna and offset antenna are arranged along with the q rotation of the positioner, it is possible to obtain the identical EIS results from either of the two antenna even with the inter-band CA tests s.  Proposal 1: Allow the FR2 OTA test system which has the offset test antenna for inter-band DL CA test cases for both CBM and IBM UEs. |
| [R4-2014921](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014921.zip) | Apple Inc. | **Impact of AoA offset on inter-band CA PSD difference**  Observation 1: At least for IBM inter-band CA requirements, AoA offsets of up to 7 degrees between two FR2 CA component carriers do not significantly impact the PSD difference assumpiton taken for the core requirement.  Proposal 1: An OTA test system configuration with AoA offsets can be considered a permitted test system for IBM FR2 inter-band CA requirements: at least for CA between n261 and n260.  Proposal 2: The applicability of a test system configuration with AoA offsets to band n262 test cases should be checked after band n262 requirements and scope of CA configurations with n262 are better understood.  Proposal 3: The applicability of a test system configuration with AoA offsets to CBM test cases should be checked after the scope of CBM requirements for FR2 CA is better understood. |

## Open issues summary

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

### Sub-topic 3-1: Offset test antennae for FR2 inter-band testing

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 3-1-1: Feasibility of offset test antennae for FR2 inter-band testing**

* Proposals
  + Alt 3-1-1-1: An IFF test set up with multiple test antennae is feasible for inter-band CA testing of UEs with IBM, but additional considerations must be made, like system calibration procedures, and QZ size characterization
  + Option 2: TBA
* Recommended WF
  + TBA

**Issue 3-1-2: Remaining open issues with offest test antennae for FR2 inter-band testing**

* Proposals
  + Alt 3-1-2-1: Impact on QZ size and quality
  + Alt 3-1-2-2: Potential to trigger different choice of optimum UE beam facing each source and impact on beam management performance
  + Alt 3-1-2-3: Applicability of potential power class specific manufacturer declarations (e.g. PC1 and PC5 may have a different optimum than PC3)
  + Alt 3-1-2-4: Feasiblity of the solution for inter-band CA with CBM
  + Alt 3-1-2-5: Feasiblity of the solution for inter-band CA with band n262

### Sub-topic 3-2: Other testability aspects related to FR2 inter-band CA

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 3-2-1: Beam correspondence for FR2 inter-band CA and shared antenna arrays**

* Proposal: Measurement procedures of beam correspondence with CA in FR2 should be the subject of further investigation, and an LS to RAN1 is needed to clarify the following:
  + inform and explain the need for enhanced mechanisms that allow for quickly changing the lead component carrier used for beam management and/or beam correspondence for CA in FR2;
  + request further study of the identified gap in current framework; and
  + consider performance enhancement procedures within CA framework for UEs with shared antenna arrays across all frequencies associated with any particular CC combination in FR2.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Issue** | **Company Comments** |
| Issue 3-1-1: Feasibility of offset test antennae for FR2 inter-band testing | Anritsu: For alt 3-1-1-1, we agree that an additional calibration and characterization procedures of QoQZ are needed. For the antenna calibration procedure, we suppose it is same as the already existing antennas such as the in-band main antenna and spurious measurement antennas. For the impact to QoQZ and QZ size, we are currently investigating the difference between the one for the main antenna and for the offset antenna. |
| Issue 3-1-2: Remaining open issues with offest test antennae for FR2 inter-band testing |  |
| Issue 3-2-1: Beam correspondence for FR2 inter-band CA and shared antenna arrays |  |

### 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.*

|  |  |
| --- | --- |
|  | **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”* |

# Topic #4: Extreme temperature conditions for all applicable FR2 UE RF test cases

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2016214](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016214.zip) | Keysight Technologies | **On extreme temperature condition testing**  Proposal 1: Based on the work presented in RAN5, RAN4 to consider ETC testing feasible while supporting 3D scans for beam peak searches/spherical coverage and TRP testing |
| [R4-2016223](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016223.zip) | vivo | **Views on FR2 extreme temperature condition testing**  Observation 1: Currently, ETC test procedure and MU assessment in RAN5 spec is FFS, decision on ETC requirements should be made in RAN4 and inform the agreements to RAN5 to complete the test cases.  Observation 2: It is common understanding that the phase shifter will drift under extreme temperature condition, but the impacts on 3D scan and peak EIRP/EIS performance is not clear.  Proposal 1: RAN4 group should confirm the feasibility of 3D scan for ETC testing, feedback from TE vendors is required.  Proposal 2: RAN4 should establish simulation to calculate the impacts of temperature on FR2 beamforming, and analyse the performance difference under 3D scan (spherical coverage and TRP) with ECT and NCT.  Proposal 3: Additionally, RAN4 should identify new MU elements related to ETC testing, and test tolerance of [x] dB is required to address the measurement impact under ETC.  Proposal 4: If 3D scan is not feasible, then the peak EIRP/EIS should be measured by locking beam peak in NTC, then apply to ETC.  Proposal 5: Considering November meeting is the initial deadline of RAN5 ETC work, if feasibility of 3D scan is confirmed, RAN4 agreements should be informed to RAN5 ASAP to align the actions for next steps.  Proposal []: Set target completion date for TE vendors to complete MU on ETC for conformance test cases that are required ETC testing for Priority 1 and Priority 2 test cases by RAN5#89 meeting in November 2020.  Proposal []: If the MU work on ETC using 3D scans has been completed by RAN5#89.  Proposal []: Â If none of the MU work on ETC has been completed by RAN5#89, only NTC will be tested |

## Open issues summary

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

### Sub-topic 4-1

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 4-1-1: Feasibility of ET conditions**

* Proposals
  + Alt 4-1-1-1: Based on the work presented in RAN5, RAN4 to consider ETC testing feasible while supporting 3D scans for beam peak searches/spherical coverage and TRP testing
  + Alt 4-1-1-2: RAN4 group should confirm the feasibility of 3D scan for ETC testing, feedback from TE vendors is required:
    - If 3D scan is feasible, then we should discuss the impacts on the requirements introduced by ETC, and also study how to define the enhanced test procedure.
    - If 3D scan is not feasible, then the peak EIRP/EIS should be measured by locking beam peak in NTC, then apply to ETC
    - Considering November meeting is the initial deadline of RAN5 ETC work, if feasibility of 3D scan is confirmed, RAN4 agreements should be informed to RAN5 ASAP to align the actions for next steps

**Issue 4-1-2: Open issues related to ET conditions which need to be addressed**

* Proposal: RAN4 to calculate the EIRP shift of each point induced by thermal effect during the 3D scan, and the deviation should be considered as one of the aspects for test tolerance; the following steps are proposed:
  + Perform simulation to calculate the impacts of temperature on FR2 beamforming, and analyse the performance difference under 3D scan (spherical coverage and TRP) with ECT and NCT
  + Identify new MU elements related to ETC testing, and test tolerance of [x] dB is required to address the measurement impact under ETC

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Issue** | **Company Comments** |
| Issue 4-1-1: Feasibility of ET conditions | Anritsu: Feasibility study is done with following aspects;   * a mechanical structure of a box in a chamber to enable 3D scan with a precondition of 30 cm quiet zone size * an availability of a chiller and a heater to support the currently defined temperature range (-10 to +55 ⁰C). |
| Issue 4-1-2: Open issues related to ET conditions which need to be addressed |  |

### 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 |
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## 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 #5: Testability enhancements to support the verification of RF requirements for FR2 DL 256QAM

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

## Companies’ contributions summary

No contributions were submitted

# Topic #6: Testability enhancements to reduce test time

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2014491](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014491.zip) | Fraunhofer HHI, Fraunhofer IIS | **Beam sweeping and test time reduction in FR2**  Observation 1: Issue to be addressed: reduction of measurement uncertainty.  Observation 2 : Issue to be addressed: reduction of measurement time.  Observation 3: Beam sweeping can be used to reduce the time needed for FR2 testing.  Proposal 1: As part of the enhanced test methods for FR2 study item, RAN4 should discuss beam sweeping techniques further. |
| [R4-2014726](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014726.zip) | Samsung | **Discussion on FR2 test time reduction**  Observation 1: most commercial power class 3 models apply 4x1 array (4 elements), which is far from 8x2 array (16 elements).  Observation 2: Even considering possibilities in the future, it would be enough to adopt 4x2 array rather than 8x2 array.  Observation 3: Different sets of measurement grids will be defined for different power classes. When deriving measurement grid, there must be trade-off between worst-case and main stream case.  Observation 4: RSRP measurement accuracy can be improved at high downlink signal level and RSRP measurement based on fine beams are feasible.  Proposal 1: adopt 4x2 array as the antenna assumption for deriving measurement grid for PC3, especially for smart phone UE.  Proposal 2: alternative way is to develop two sets of measurement grids for PC3, one is the same as current grids based on 8x2 array assumption, the other is relatively sparse grids based on 4x1 (or 4x2) assumption. Applicability depends on UE declaration.  Proposal 3: RAN4 study RSRP accuracy at high downlink signal level and then check if RSRP could take place of EIS search as baseline for RX beam peak search.  Proposal 4: For EIRP test of UL MIMO including TX beam peak search, only one link polarization is enough.  Proposal 5: For EIRP test when TX diversity (dual polarization transmission) is activated, only one link polarization is enough. |

## Open issues summary

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

### Sub-topic 6-1: Potential test time reduction techniques

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 6-1-1: Collection of potential test time reduction techniques for RAN4 analysis in future meetings**

*The intention of this issue is to collect all companies’ proposals of potential test time reduction teqniques for future consideration by RAN4. The proposals below are captured as alternatives for ease of labeling, but it is not necessary to down-select the alternatives at this stage.*

* Proposals
  + Alt 6-1-1-1: As part of the enhanced test methods for FR2 study item, RAN4 should discuss beam sweeping techniques further
  + Alt 6-1-1-2: Adopt 4x2 array as the antenna assumption for deriving measurement grid for PC3, especially for smart phone UE.
  + Alt 6-1-1-3: Develop two sets of measurement grids for PC3, one is the same as current grids based on 8x2 array assumption, the other is relatively sparse grids based on 4x1 (or 4x2) assumption. Applicability depends on UE declaration
  + Alt 6-1-1-4: RAN4 study RSRP accuracy at high downlink signal level and then check if RSRP could take place of EIS search as baseline for RX beam peak search
  + Alt 6-1-1-5: For EIRP test of UL MIMO including TX beam peak search, only one link polarization is enough.
  + Alt 6-1-1-6: : For EIRP test when TX diversity (dual polarization transmission) is activated, only one link polarization is enough.
  + Other proposals are not precluded

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Issue** | **Company Comments** |
| Issue 6-1-1: Collection of potential test time reduction techniques for RAN4 analysis in future meetings |  |

### 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.*

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| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
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| YYY | Company A |
| Company B |
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## 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 #7: Testability aspects for the introduction of the new band n262

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| T-doc number | Company | Proposals / Observations |
| [R4-2014922](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014922.zip) | Apple Inc. | Band n262 testability  The work on permitted methods further includes scope for RF, RRM, and demodulation measurement setups. According to our understanding, the following aspects of TR38.810 should be considered in scope for this effort:  - RF test setup  - Far-field criteria for the DFF system (Clause 5.2.1.2)  - IFF near-field/far-field boundary and path loss (Clause 5.2.3.2)  - Determine which uncertainy elements are impacted by the new frequency range and determine a preliminary assessment of their value  - RRM test setup  - Reference point SNR derivation (Clause 6.2.1.4.3)  - Determine which uncertainy elements are impacted by the new frequency range and determine a preliminary assessment of their value  - Demodulation test setup  - Reference point SNR derivation (Clause )  - Determine which uncertainy elements are impacted by the new frequency range and determine a preliminary assessment of their value  The work on new enhancements related to Objectives 1 through 6 should be directly integrated into the relevant discussion, such that:  - Low UL / high UL test cases: an evaluation of the scale of the testability issues associated with the identified test cases is needed to determine how much improvement is necessary (we note that this also depends on the outcome of the extension of the permitted method to this frequency range)  - For the polarization mismatch objective, the preliminary assessment of uncertainty should include the new frequency range into the evaluation scope  - For the FR2 CA objective, it is proposed to first check the progress of core requirement work to understand the scope of CA configurations which include band n262  - Since work has not yet started on Objectives 4 – 6, the related discussions should take the new frequency range into account. |
| [R4-2016224](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2016224.zip) | vivo | Discussion on Testability issue of 47GHz band  Observation 1: The increasing in radiated pathloss for 47 GHz systems is about 1dB when compared to 43.5 GHz.  Observation 2: Re-define the measurement grids for 47GHz band is not needed.  Proposal 1: The study of the enhanced test method should be based on 48.2GHz upper limit.  Proposal 2: Adopt the effective antenna aperture approach, similar to the agreed concept for FR1 RTS test method, for FR2 enhanced test method to reduce the measurement distance.  Proposal 3: The effective antenna aperture approach should be applied for all the PCs, reasonable assumption of Deff should be defined based on the feedback of OEMs.  Proposal 4: No new MU element is needed for n262 band, detailed MU assessment work should be done in RAN5.  Proposal 5: The Maximum SNR range assessment of the permitted test system for band n262 is required. |

## Open issues summary

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

### Sub-topic 7-1: General agreements related to the extension of test method applicability to n262

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 7-1-1: Upper frequency limit**

* Proposal: The study of the enhanced test method should be based on 48.2GHz upper limit.

**Issue 7-1-2: Antenna aperture**

* Proposal: Adopt the effective antenna aperture approach, similar to the agreed concept for FR1 RTS test method, for FR2 enhanced test method to reduce the measurement distance. The effective antenna aperture approach should be applied for all the PCs, reasonable assumption of Deff should be defined based on the feedback of OEMs.

**Issue 7-1-3: MU**

* Proposal: No new MU element is needed for n262 band, detailed MU assessment work should be done in RAN5.

### Sub-topic 7-2: Applicability of permitted test methods to n262

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 7-2-1: Open issues with the RF test setup for applicability of permitted test methods to n262**

* Proposal: According to [R4-2014922](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014922.zip)
  + Far-field criteria for the DFF system (Clause 5.2.1.2)
  + IFF near-field/far-field boundary and path loss (Clause 5.2.3.2)
  + Determine which uncertainy elements are impacted by the new frequency range and determine a preliminary assessment of their value

**Issue 7-2-2: Open issues with the RRM test setup for applicability of permitted test methods to n262**

* Proposal: According to [R4-2014922](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014922.zip)
  + Reference point SNR derivation (Clause 6.2.1.4.3)
  + Determine which uncertainy elements are impacted by the new frequency range and determine a preliminary assessment of their value

**Issue 7-2-3: Open issues with the demodulation test setup for applicability of permitted test methods to n262**

* Proposal: According to [R4-2014922](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014922.zip)
  + Reference point SNR derivation (Clause 7.2.1.3.1)
  + Determine which uncertainy elements are impacted by the new frequency range and determine a preliminary assessment of their value

### Sub-topic 7-3: Applicability of test method enhancements to n262

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 7-3-1: Open issues with the applicability of test methodology enhancements to n262**

* Proposal: The work on new enhancements related to Objectives 1 through 6 should be directly integrated into the relevant discussion, such that:
  + Low UL / high UL test cases: an evaluation of the scale of the testability issues associated with the identified test cases is needed to determine how much improvement is necessary (we note that this also depends on the outcome of the extension of the permitted method to this frequency range)
  + For the polarization mismatch objective, the preliminary assessment of uncertainty should include the new frequency range into the evaluation scope
  + For the FR2 CA objective, it is proposed to first check the progress of core requirement work to understand the scope of CA configurations which include band n262
  + Since work has not yet started on Objectives 4 – 6, the related discussions should take the new frequency range into account.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Issue** | **Company Comments** |
| Issue 7-1-1: Upper frequency limit |  |
| Issue 7-1-2: Antenna aperture |  |
| Issue 7-1-3: MU |  |
| Issue 7-2-1: Open issues with the RF test setup for applicability of permitted test methods to n262 |  |
| Issue 7-2-2: Open issues with the RRM test setup for applicability of permitted test methods to n262 |  |
| Issue 7-2-3: Open issues with the demodulation test setup for applicability of permitted test methods to n262 |  |
| Issue 7-3-1: Open issues with the applicability of test methodology enhancements to n262 |  |

### 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** |
| #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”* |

# Topic #8: Rapporteur input

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2014918](http://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_97_e/Docs/R4-2014918.zip) | Apple Inc., vivo | **Updated work plan for FS\_FR2\_enhTestMethods**  Observation 1: We note that Objective 7 implies that the study on enhanced test methods includes scope for RF, RRM, and demodulation with the goal of extending the frequency applicability to include the new band n262.  Observation 2: The scope of any uncertainty assessment is understood to include the identification of potential new uncertainty elements and the derivation of an initial estimated value of its contribution.  Proposal 1: It is proposed to approve the updated work plan for the Study on enhanced test methods for FR2. |

## Open issues summary

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

### Sub-topic 8-1

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 8-1-1: Updated work plan**

* Proposal: It is proposed to approve the updated work plan for the Study on enhanced test methods for FR2, as captured in R4-2014918

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Issue** | **Company Comments** |
| Issue 8-1-1: Updated work plan |  |

### 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 |
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| 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:* |

*Recommendations 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 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”* |