**3GPP TSG-RAN WG4 Meeting # 97-e R4-200XXXX**

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

**Agenda item:** 12.3.2.3

**Source:** Apple

**Title:** Email discussion summary for [97e][137] NR\_RF\_FR2\_req\_enh2\_Part\_3

**Document for:** Information

# Introduction

In RAN 89e, new WID on NR RF enhancements for FR2 is approved [1] with the following objectives

* UL gaps for self-calibration and monitoring. [RAN4 RF/RRM, RAN2] Study and, if feasible, introduce UE specific and NW configured gap for general self-calibration and monitoring purposes including
	+ - PA efficiency and power consumption
		- Transceiver calibration due to temperature variation
		- UE Tx power management
		- Others self-calibration and monitoring are not precluded
	+ **Phase 1:** Study and clearly identify the performance gain over the current baseline (Rel.16 requirements) Study of RF performance evaluation/testability related to UE self-calibration and monitoring. Study network impact of UE emissions during UL gap, if any.
	+ **Phase 2:** Specify the UL gap configuration(s), related UE capability and interruptions, if needed, based on the identified performance gain in Phase 1 and UE fall back behaviour i.e. if gaps are not available for UE requesting gaps.

# Topic #1: Study and identify the performance gain, evaluation and NW impact of UL gap

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2014218**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014218.zip)[**R4-2016560**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016560.zip) | Apple | Observation 1: Due to the regulatory requirement on RF exposure limits, there is a need for UE to perform additional MPR as a function of peak Tx EIRP and uplink duty cycle. For example, for a peak EIRP = 26 dBm and duty cycle = 20%, the required MPR is around 6 dB.Observation 2: There exists a “critical range” for an NR FR2 radio, beyond which if a human target is present, no MPR is required to remain RF exposure compliant. Observation 3: There are many realistic mobile device (smartphone, tablet) handgrips, for which a human appendage does not lie in the field of view of a 5GNR mmW UL beam. In such scenarios, additional MPR could be avoided if human target presence/absence in close proximity could be detected by the UE equipped with an adequate proximity sensor. Such proximity sensing function can be useful even for other category of devices that transmit at higher power (eg. CPE for FWA applications).Observation 4: Significant impact to UL throughput with QPSK and 16QAM is observed as a function of MPR:* For QPSK, 12% to 75% reduction in UL throughput was observed as the MPR is varied between 1 dB and 8 dB.
* For UL 16QAM, 10% to 49% reduction in UL throughput was observed as the MPR is varied between 1 dB and 8 dB.

Observation 5: Application of MPR to Transmit power has a significant impact (up to 33%) on UL range.Observation 6: Significant impact to system throughput observed for a channel BW of 100 MHz and Inter Site Distance of 200 meters:* 5-percentile UL throughput reduced by 52% at an MPR = 6 dB.
* Mean UL throughput reduced by 13% at an MPR = 6 dB.

Observation 7: A Proximity Sensor (PS) may not be able to concurrently operate with a 5GNR FR2 transceiver. This requires gaps in the airtime of 5G NR FR2 operation to allow for PS operation.Observation 8: By complying with existing spurious emission limits for FR2, no undue interference to the regular 5G NR FR2 signal for the given FR2 band is expected.Observation 9: * Online transceiver calibration can mitigate the various impairments due to temperature variation in FR2 RF.

Observation 10: * NW configured and UE specific self-calibration and monitoring gap without emission has minimum network performance impact.

Proposal: * Introduce UE specific and NW configured gap for general self-calibration and monitoring purpose.
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| [**R4-2014393**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014393.zip) | CATT | Proposal: The behaviors of UE in UL gap should be identified such as if UE transmits signal in the gap, what’s Tx calibration signal details including BW, power level, etc before doing the studies in phase 1. |
| [**R4-2014516**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014516.zip) | Nokia, Nokia Shanghai Bell | For progressing detailed evaluations RAN4 should first agree assumptions for the studies. In our view at least the following aspects should be considered and the corresponding assumptions agreed to allow companies to conduct comparable studies;* UL gap assumptions like UL gap rate per UE using the Rel-15 consideration as a starting point and if feasible, even less frequent gaps could be studied.
* Agree self-calibration and monitoring areas to be studied for UL gaps i.e. agree explicit list of self-calibration and monitoring aspects i.e. if other aspects but the ones listed in the WID objectives [1] are to be considered for the study, they should be explicitly agreed.
	+ - PA efficiency and power consumption
		- Transceiver calibration due to temperature variation
		- UE Tx power management
		- Others self-calibration and monitoring are not precluded
* Identify what kind of performance and requirement enhancements self-calibration could provide and what enhancements should be studied (e.g. reduced MPR etc)
* Evaluate system impacts considering both losses due to UL gaps and performance enhancements
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| [**R4-2014590**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014590.zip) | Intel Corporation | * Observation 1: The following Tx requirements can be improved over current Rel-16 requirements with self-calibrations over UL gaps: Minimum peak EIRP, spherical coverage, MPR/AMPR, configured transmit power, IQ image and carrier leakage.
* Observation 2: UL gaps for self-calibrations should bring net throughput gains. Any throughput loss due to UL gaps should be compensated by throughput increase due to performance gain.
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| [**R4-2014716**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014716.zip) | Qualcomm Incorporated | The first part of the WI should concentrate on the understanding the performance benefits over the current baseline Rel-16 requirements and then comparing those potential network impacts. The benefits visible to the network in UE UL domain are * more UL power to enhance the coverage
* less MPR allowance to enhance the high MCS coverage
* better EVM to improve throughput
* Better emissions performance to reduce adjacent channel interference
* More accurate power control

Observation 1: WI suggests the benefit of the UL gaps should be visible in UE requirements compared to the Rel-16Observation 2: What is UE behaviour in UL gap needs to be agreed for further analysis.Our view is that the minimal impact to the network is when UE does not transmit at all i.e. conforms to the OFF-power requirements. UE can internally route the calibration signal and then network can re-use the resources to the other users. Proposal: UE behaviour during the gap is to conform to existing OFF power requirements  |
| [**R4-2014963**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014963.zip) | vivo | Observation 1: Two types of gaps, i.e. RRG and TG were discussed in R15. RRG is assumed to be used for PA calibration, and TG is used for calibration of IQ image and LO feedthrough.Observation 2: Although RRG can maintain 1Tx transmission while TG cannot, it would require more restrictions on network scheduling to achieve such 1Tx and the performance of such 1Tx can be poor.Proposal 1 Study the enhancement on RF requirements using UL gap compared to the “no gap” case, and the loss due to restricted scheduling also needs to be studied.Proposal 2 The gap period and gap duration need careful considerations in the study phase. Proposal 3 Study the potential signaling impacts due to the introduction of UL gap.Proposal 4 First priority is to study TG in R17 and if time allows further study the necessity/benefit of RRG over TG. |
| [**R4-2015349**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015349.zip) | OPPO | 2.1 Self-calibration background*Observation 1: It was agreed power calibration gaps can be scheduled by the UE itself autonomously in Rel-15.**Observation 2: It was agreed requirements were defined based on UEs without power calibration gaps in Rel-15.*2.2 Rel-17 objectives*Proposal 1: Take UEs without power calibration gaps in Rel-16 as baseline to analyze performance gain of power calibration gap.**Observation 3: Power calibration is UE implementation specific and performance gain is different from UE to UE.**Proposal 2: Compare performance of UEs with and without power calibration gaps to better understand gain of this feature, however, no performance gain requirements are defined.**Proposal 3: Emissions need to be controlled during the calibration gap and tests need to be considered* |
| [**R4-2016061**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016061.zip) | Ericsson, Sony | Observation 1: When previously analysed as part of the NR rel-15 NR core Work Item, no need fin introducing Self-calibration or monitoring GAP(s) was found.Observation 2: A clarification is needed with regards to the possible side effects on gNB given the scheme in Figure 1 (from [4]) if the UE caters for calibration itself.Proposal 1: We propose that the claimed MOP/ACLR gains and UE cost aspects with PCG be elucidated fully in relation to other low-complexity linearization methods, BS scheduling complexity, and network performance before any decision of PCG specification is taken. |
| [**R4-2016536**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016536.zip) | Huawei, HiSilicon | Observation 1: PA calibration gap is required because of a specific implementation, i.e. DPD loop via OTA.Observation 2: the potential impact to network performance introduced by PA calibration gap need to be carefully studied.  |

## Open issues summary

Sub topic 1-1: Candidates metric which can be used for performance gain evaluation compared with Rel-16 UE with no calibration gap assumed

* more UL power to enhance the coverage
* less MPR allowance to enhance the high MCS coverage
* better EVM to improve throughput
* Better emissions performance to reduce adjacent channel interference
* More accurate power control
* others

Sub topic 1-2: For performance gain and NW impact evaluation purposes, should the study on UL gap be further classified into two categories based on UE behavior during the gap

* No UL scheduling during the gap is needed. NW can assign those resources to other UE for UL transmission.
* UL scheduling, including dedicated time and frequency resources reserved for self-calibration and monitoring, during the gap is needed. NW cannot assign those resources to other UE for UL transmission.

Sub topic 1-3: Candidate UL gap usage include

* UE power/coverage enhancement
* PA calibration
* Transceiver calibration

Sub topic 1-4: Summary of views on identified performance gain and RF performance evaluation/testability over the current baseline (R16 requirements)

Sub topic 1-5: Summary of views on identified NW impact

## Companies views’ collection for 1st round

### Open issues

Moderator: Please add your comments to sub-topic 1-1 and 1-2 here. Instead, you can directly comment to CR draft.

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| **Company** | **Comments** |
| XXX | Sub topic 1-1: Sub topic 1-2:….Others: |
| CATT | Sub topic 1-2: For performance gain and NW impact evaluation purposes, should the study on UL gap be further classified into two categories based on UE behavior during the gapIn our contribution, we raised the question that UE behaviors should be clarified in the two scenarios. The behavior assumption alignment is necessary for the further discussion of both gain or NW impact. And NW needs to know more to decide how to schedule this UE or other UEs. |
| vivo | Sub topic 1-1:If the gap can be used for transceiver calibration, the in-band emission can be improved. Therefore, the 4th bullet can be revised to “Better emissions performance to reduce adjacent channel interference (ACLR) or in-band interference (IBE)”Sub topic 1-2:The gap with scheduling (RRG) is more complicated and may constrain the system performance as discussed in Rel-15. So it may be easier to study the gap without scheduling (TG) first. Sub topic 1-3:The calibration for phase shifter can also be considered and we are not sure whether it is already included in the first bullet “UE power/coverage enhancement”.Sub topic 1-4:On RF performance evaluation:In our understanding, the R16 baseline should be the RF performance requirements defined in current spec, and the assumption behind is that UE has no UL gap for calibration. Note that RAN4 requirements are defined for the worst case. Therefore, the baseline assumption should be UE can not perform calibration since there is no gap guaranteed. Note that in this case UE is expected to meet R16 requirements.Based on this baseline assumption, it is proposed to further evaluate the RF performance gain if gap is introduced in R17.On testability:The UE supporting enhanced RF performance when UL gap is provided can report capability to NW, and the test case can be designed by testing UE RF performance when configuration / scheduling of UL gap is available. The testability issue of UL gap can be the same as R15/16 testability and no additional issues are identified.Sub topic 1-5:In our view, the NW impact is highly related to the details of UL gap schemes. The impact can be the restriction in scheduling and the potential UL interference when calibration is performing. It would be better if some performance metrics can be defined. It would be good if some infra-vendors can have some input on this. |
| Intel | Sub topic 1-1: We see it is possible to have performance improvement on all listed aspects. We also emphasize that UL gaps should bring net system performance gain in overall network throughput, cell coverage, etc. Sub topic 1-2: Two categories of UL gaps can be considered. Gaps without UL transmissions during which UE can do any calibrations at their own decision. Gaps with UL transmissions during which UL resources (PRB allocations, waveform, power control, etc. ) need to be specified in the spec and scheduled by network. UE should be emission compliant during transmissions in UL gaps. |
| Qualcomm | 1-1: Seems like a good list of metrics but the agreement should focus on testable improvements with and without gaps.1-2: Studying both options would need network simulations. Is there a proposal for simulation assumptions for both cases? Or how will we analyse the impact?1-3: “UE power/coverage enhancement” seems overlap with subtopic 1-1 items. Does the proposal include power class modifications? PA calibration and Transceiver calibration seems to be UE internal issue and it is not clear how a define 3GPP requirement for these. 1-4: Our view is to take R16 requirement as baseline and define what is different for the UE with gaps. 1-5: Agree with vivo here that some agreement on what is the gas is needed before we can analyse the impact to NW.  |
| Verizon | 1-1: Agree to target on this candidates metric for performance gain evaluation compared with Rel-16 UE 1-2: It would be better to consider two UL scheduling categories in the study |
| OPPO | **Sub topic 1-1: Candidates metric which can be used for performance gain evaluation compared with Rel-16 UE with no calibration gap assumed**It is possible to get some improvements from the UE power/emission, etc. but how to do the comparison with system throughput loss is unclear.**Sub topic 1-2: For performance gain and NW impact evaluation purposes, should the study on UL gap be further classified into two categories based on UE behavior during the gap**Both cases can be consider in the evaluation since finally this will impact NW scheduling.**Sub topic 1-3: Candidate UL gap usage include**Depends on UE implementation since some UEs may need PA calibration, others may need transceiver calibration, etc. |
| Sony | Sub topic 1-1: To our understanding, it could be helpful to first narrow down the scope on the candidate calibration type (e.g. issues discussed in sub topic 1-3), and then select the metric based on the agreed calibration type. Sub topic 1-4: To our understanding, it is also possible to carry out real time PA calibration without a calibration gap (transparent to the scheduling). For example, a UE can transmit on one RF chain and using the other RF chain for feedback. Therefore, we would like to understand the necessity to introduce a calibration gap, and how much gain it can provide compared to the case that mentioned above. Sub topic 1-5: The complexity and the required overhead of different categories of calibration gap on the network scheduling needs to be carefully analyzed. |
| Nokia | Sub topic 1-1: The list of metrics look good. In the end the performance gains needs to be visible in the actual testable requirements, not only in the evaluations.Sub topic 1-2: Ideally all the impacts should be studied and well understood before decisions. However, aligned assumptions for the studies need to be agreed so that comparisons of the results are also possible.Sub topic 1-3: The proposed list is ok for the studies. In the end the benefits should be visible as improved UE requirements.Sub topic 1-4: The aim of the study should be to identify what testable UE requirement improvements can be obtained with gaps on top of the Rel-16 requirements. Sub topic 1-5: It is not possible to evaluate impacts before agreeing further details for the studies. |
| MTK | 1-1: We expect a methodology to quantify the performance gain. We also want to mention that although there are many benefits that can be brought by introducing the gap, it should still be up to UE implementation on what to do within each gap. We should not mandate UE can achieve all listed benefits in one shot.1-2: Similar question as QC. We are more interested in the next step on how to quantify the impacts  |
| Samsung | Sub topic 1-1: the metric list seems good. It is helpful to distinguish which metric is obtained by which type of calibration. So we agree with Sony that it is necessary to check if both PA calibration and transceiver calibration are feasible, especially for PA calibration. Moreover, UL gap enhancement may improve emission performance, but emission requirement is subject to no change. So the benefits may be finally absorbed by MPR enhancement.Sub topic 1-2: though we think the gap without scheduling is easier, both options can be considered at current stage to fully evaluate the gain and impact.Sub topic 1-3: we are clear about PA calibration and transceiver calibration, but not sure what is the detailed UE behavior for “UE power/coverage enhancement” option.Sub topic 1-4: Agree Rel-16 requirements as baseline. But the R16 baseline need to be clarified. Is R16 baseline no UL gap or with autonomous UL gap? Previous discussion shows that UE can perform autonomous UL gap. |
| Xiaomi | Sub topic 1-1: The list looks fine for us.Sub topic 1-2: Full evaluation is needed before we make decision at this stage. The metrics defined in topic 1-1 can be used to evaluate the two options.Sub topic 1-3: The listed items might be as “optional” that we don’t want every UE to do all of them. |
| NTT DOCOMO, INC | Sub topic 1-1:The list looks good.The performance gain should be visible in the actual testable requirements. Otherwise, it may be meaningless to introduce this feature from NW and operator side. |
| Apple | Subtopic 1-1: We agree with the metrics. Different sub-set of those metrics can be used for evaluation of different gap usage. We can further decide the proper metrics for each UL gap usage. Subtopic 1-2: To evaluate NW impact, we agree that UL gap be further classified into two categories based on UE behavior during the gap. For gap without UL grant, the resource can be used to schedule other UE UL transmission. Subtopic 1-3:UL Tx power management, PA calibration and transceiver calibration are the main usages in our view. Other usages are not excluded. Subtopic 1-4:Performance gain and testability can be discussed for each UL gap usage. * UL coverage have been challenges for FR2 system. For UL tx power management, while satisfying the regulatory requirements, UL gap can enable UE to have more accurate power control and avoid unnecessary P-MPR, which eventually result in the UL coverage enhancement. Test cases can be designed to verify proper UE behavior with and without UL gap configured.
* For Transceiver calibration, UL gap can benefit EVM performance and emissions performance. The related performance gain should be demonstrated when UL gap is configured
* For PA calibration, it has been well discussed in R15. Generally, it is expected that PA calibration can reduce MPR to enhance the high MCS coverage.

Sub-topic 1-5: Network impact is related to the usage of UL gap. When no UL grant is needed, the UL resource can be used by other UE, then the primary impact is scheduling complexity while network throughput impact is minimum. When UL grant is needed, network impact is related to the required gap duty cycle.  |
| Ericsson | Sub-topic 1-4: We would like to see careful analysis on the gain with gap compared to the impact on NW scheduling complexity/performance and possible end user impact. E.G How much better pwr accuracy can be expected? In our view the UE can, and is today, performing PA calibration without any need of calibration gap. The situation on the BS is similar, no need for gap for PA calibration. Sub-topic 1-5: Hard to evaluate in detail at this stage. NW impact will depend on gap length, periodicity, but also on how many RRC connected UE there are in the cell, how the UEs are distributed within the cell (e.g. UEs might be configured with additional gap’s for inter freq measurements if closer to cell edge). The NW and end user impact is not neglectable.  |

### CRs/TPs comments collection

Moderator: Please add comments to CR drafts here.

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| **CR/TP number** | **Comments collection** |
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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:* |

*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”* |