**3GPP TSG-RAN Meeting # 89-e RP-201609**

**Electronic Meeting, September 14-18, 2020**

**Agenda item:** X.X

**Source:** Moderator (Nokia)

**Title:** Email discussion summary for Rel-17 FR2 RF work area

**Document for:** Information

# Introduction

This document will summarize companies’ inputs regarding the scope of the FR2 RF work area for Rel.17.

# FR2 RF Work Area in Rel-17

## Document submitted to RAN#88-e

One input contribution related to Rel-17 FR2 RF work area was submitted to RAN#88-e in [1]

## Issues related to Rel-17 FR2 RF work area for discussion

* Sub-topic 1-1: Identify FR2 RF sub-work areas for Rel-17
	+ Identify FR2 RF areas needing new requirements or further enhancements in Rel-17 (e.g. FR2 RF aspects, which were originally included to the Rel-16 RF FR2 work item but could not be completed in Rel-16, FR2 RF areas requiring further enhancements in Rel-17 or new FR2 RF aspects)
	+ Provide also justifications for the proposed FR2 RF sub-work areas
* Sub-topic 1-2: WI objectives for each identify Rel-17 FR2 RF sub-work area
	+ Identify detailed scope and objectives for each Rel-17 FR2 RF sub-work area proposal
* Sub-topic 1-3: Any other issues

## Companies’ views

*Interested companies to provide comments and proposals for the sub-topics in the following sections*

### Sub-topic 1-1: Identify FR2 RF sub-work areas for Rel-17

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| **Company** | **Comments and proposals** |
| Apple | We observe that the currently ongoing Rel-16 FR2 RF work item has gone through some descoping, and we anticipate some leftover items to be proposed for Rel-17 work. It would be useful to consider these upon the conclusion of the RAN4 #96e meeting.Considering newly proposed work areas, we would like to propose the following three, further noting that all three work areas have been described in RP-201109 [1]:1. Beam correspondence with localized beam sweeping
2. Non-simultaneous uplink (NSU) on non-contiguous carriers in FR2
3. FR2 UE antenna element scaling

In the case of BC with localized beam sweeping, it is our understanding that the RAN1 related effort may have been already covered in R17 FeMIMO WI, e.g. “Unified TCI framework for DL and UL beam indication”, where the focus is on the signaling solution to enable the localized beam refinement functionality. Upon RAN1 successfully completion of this work, RAN4 effort should specify the UE requirements for the feature. In the case of NSU, we would like to emphasize that if inter-band UL CA within FR2 becomes part of the Rel-17 work scope, then this feature is, in our understading, essential to enabling inter-band UL CA for handheld form factors.In the case of FR2 UE antenna element scaling, it is useful to solicit other companies’ feedback on how to structure the work between RAN4 and RAN1. One option can be to list the work objective in the RAN4 WID with secondary responsibility given to RAN1 to enable the necessary signaling.Based on the comments in RRM work area email thread, we further move the discussion of studying and introducing UL gap for UE self-calibration and monitoring to FR2 RF email thread also. * There have been a lot of interests to further enhance FR2 coverage, signal quality and UE performance, including both power efficiency and overall system throughput.
* Due to unavoidable hardware sharing, various identified FR2 enhancements have to rely on and benefit from a periodical UL gap, where UE can perform calibration and measurement over the air or through the internal loop without interrupting UL transmission/reception
	+ - PA efficiency and power consumption
		- Transceiver calibration due to temperature variation
		- UE Tx power management
		- Others self-calibration and monitoring are not precluded
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| Nokia | In our view the following FR2 RF sub-work areas should be considered for Rel-17 in order to complete the FR2 RF enhancements started but not completed in Rel-16. Also it is important to continue further development of FR2 for practical FR2 deployments and different operator scenarios and spectrum allocations. Some of the areas are dependent on Rel-16 FR2 progress and details need to be checked after the RAN4#96-e meeting progress.* Inter-band DL CA enhancements
	+ Low-Low and High-High cases
	+ Common Beam Management (CBM)
	+ Including RF and RRM requirement aspects
* Inter-band UL CA
	+ specify inter-band UL CA for two bands including both CBM and IBM (Independent Beam Management)
	+ study on non-simultaneous UL for inter-band
* Potentially intra-band CA enhancements
	+ Need for more than 3 UL sub-blocks?
* Beam Correspondence enhancements (details also depends on Rel-16 progress)
	+ Study BC enhancements and requirements for dynamic radio conditions (in realistic FR2 deployments conditions vary significantly and it is important to ensure that UEs are able to have and keep good beam correspondence)
* MPE enhancements including MPE enhancements for beam management purposes e.g. introduce UE’s MPE related reports to target beams/cells to allow the source gNB to optimize beam management
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| Qualcomm | WE agree that Inter-band DL CA should be addressed in Rel.17 as proposed by NokiaFor the CA related proposals (DL and UL) we would like first to see some combinations requested by operators before proceeding with the work. We understand these are the next enhancements inline but need to see demand before starting the actual work, also there will be different issues depending on the combinationsFor the intra-band CA enhancements, we would also like to see operator demands for the scenario with more than 3UL blocks. Which band would this be for?For the beam correspondence enhancements, it should be clarified why there is a need for an enhancement in a dynamic environment. In our understanding, the beam correspondence performance has nothing to do with the environment(static or dynamic). The mapping between DL and UL beams in the UE has nothing to do with the environment or SNR. This proposal seems to be for enhancements of beam management that should be treated in RRM. |
| OPPO | In our view, the Rel-16 left over items mostly can be included in Rel-17 work item, however, it doesn’t mean all the left over issues will be automatically be included. The items with no much interest in Rel-16 is expected to be no much interest either in Rel-17, it is not recommended to be included.New items can be considered but shall be keep in a low level and be really important and urgent, considering the difficult discussion progress RAN4 has confront in Rel-16 and also the uncertainties in meeting format. If e-meeting continues, then we should keep our target more focus than Rel-16, we shall be confident to complete what we put into the Rel-17 WID rather than remove them in the late stage. |
| MediaTek | * About “FR2 UE antenna element scaling”, current core requirement only indicates requirement and has no limitation on antenna element. We think how many active antenna element for specific scenario(s) shall be up to UE implementation.
* About “inter-band CA”, RAN4 only has a few progress on inter-band DL CA in Rel-16, we think 3gpp shall focus on remaining inter-band DL CA issues in Rel-17 firstly.
* About “beam correspondence enhancement”, we think 3gpp shall focus on testability firstly, especially that we know there are still many test enhancement topics are under discussion.
* About “MPE enhancement”, we are not sure whether it is worth to introduce MPE enhancement as part of beam management mechanism while consider the system complexity.
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| LGE | * Sub-topic 1-1: Identify FR2 RF sub-work areas for Rel-17
	+ Inter-band UL CA
		- specify inter-band UL CA for two bands including both CBM and IBM
		- Non-simultaneous uplink (NSU) on non-contiguous carriers
	+ Inter-band DL CA
		- Inter-band CA within the same freq. group (e.g. 28GHz + 28GHz) with CBM as baseline
		- Inter-band CA between different freq. groups (e.g. 28GHz +37GHz) with CBM as optional
	+ MPE enhancements
		- Dynamic duty cycle adjustment to resolve RLF problems
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| Samsung | We agree with Nokia that inter-band DL CA and beam correspondence enhancement can be considered as objectives for Rel-17 FR2 UE RF WI. It is natural to complete inter-band DL CA leftover issues in Rel-17. Based on beam correspondence discussions in Rel-16, companies observed necessity to enhance beam correspondence when network signal is poor. |
| Intel | 1) Inter-band DL CA: RAN4 needs to continue work on CBM solutions in Rel-17. Based on operators request, RAN4 may need to study extension to 3 bands case.2) Inter-band UL CA: Propose to study IBM and CBM solutions in Rel-17. 3) Non-simultaneous UL for inter-band and/or intra-band CA: The overall system benefits of NSU are unclear comparing to single carrier UL case. Support of NSU does not increase UE throughput (one of key motivations of CA concept) and has limited benefits in terms of scheduling flexibility. Do not see the need for enhancements.4) Beam correspondence: Support Nokia proposal to “Study BC enhancements and requirements for dynamic radio conditions”. In real deployments, high mobility degrades beam correspondence performance since during the UE Rx beam sweeping in high mobility, the assumption that AoA and received power of DL reference signals keep unchanged does not hold, especially when network only configures SSB reference signals and UE has to rely on multiple SSB bursts to finish Rx beam sweeping. In Rel-17, the mechanism to reduce the mobility impact on beam correspondence performance shall be studied and specified.5) MPE enhancements: We support Nokia’s proposal. Other enhancements can be studied as well. Also, RAN1 has an ongoing work on in the scope of feMIMO WI and further alignment with RAN1 is needed.6) Antenna scaling: We are supportive to study FR2 RF specific power saving methods including antenna scaling. The impact on performance/coexistence is unclear and study stage is needed before a normative work can be done. |
| Ericsson | **Ericsson proposed objectives for FR2 WI:*** UL CA enhancement: reduction in MPR for a UE behavior in accordance with RAN1 rule on UE Tx power prioritization between SCells defined in TS 38.213.
	+ constant PSD across CCs not likely at maximum power.
* Beam Correspondence enhancements for initial access i.e. based on SSB and based on PRACH power control
* Enhancement of FR2 accuracy requirements (reduction of tolerances) for configured maximum power and absolute (open loop) power control.
	+ Reduction of tolerances for configured output power (Pcmax) not to allow undue power back-off at maximum power (build on experience gained since Rel-15 specification), possibly accommodated by specification of a new power class
	+ Absolute power tolerance: tighter requirements at maximum power setting to align with the tolerance for the power class to improve performance of open-loop power control
* Specify MOP requirements (configured output power) for UE-specific P-Max and cell-specific P-Max limitations.

**Comments on objectives proposed by Apple**:1. BC with localized beam sweeping: beam sweeping should not be a requirement for beam correspondence that is fundamental for FR2 operation. Moreover, this is not possible during initial access.2. NSU: We do not support the proposal on simultaneous uplink (NSU) on non-contiguous carriers in FR23. The RAN4 requirements do not mandate a specific number of antennas, which is transparent to the gNB. Unclear how any scaling would be specified and its impact on performance. This should be up to UE implementation and therefore no standard work is needed.**Comments on objectives proposed by Nokia**:We support proposals on DL inter-band CA (complete outstanding requirements for CBM)MPE enhancements: MPE in beam management is included in the RAN1 led Rel-17 WI FeMIMO. So no further MPE work in is needed under FR2 WI. RAN4 will develop requirements for MPE based on the RAN1 work under FeMIMO WI. |
| Sony | **For inter-band CA:** * We agree with Nokia that the inter-band DL CA requirement should be continued in Rel-17 according to the RAN4 agreement.
* We are also fine with including the inter band UL CA in Rel-17 WI since it was dropped out during Rel-16 discussion due to the time limitation.

**For Beam correspondence:** * We support Nokia’s proposal to study BC enhancements and requirements for dynamic radio conditions (e.g., SINR condition): The current BC capability without uplink beam sweeping (bit 1/0) is not sufficient to indicate the UE BC performance in the field with varied SINR and DL RS resources. Possible enhancement on enabling UE indicating the BC capability to the network under dynamic SINR condition can be studied.
* We also think it is critical to define the requirement for BC during the initial access: Due to the lack of uplink beam sweeping, the UE autonomously selected uplink beam is the only way for UE to rely on to access the FR2 network, and SSB is the only reference signal the UE can use. For Rel-16, the BC based on SSB is an optional feature, which means there is no guarantee that the UE can autonomously select the uplink beam based on SSB only. Therefore, the requirement of BC during the initial access becomes necessary.

**For MPE enhancement:**we think beam management based MPE enhancement is in the scope of RAN1 discussion and it is already included in Rel-17 FeMIMO WI. Therefore, RAN4 does not need to discuss this unless there would any requirement to be defined.**For UE antenna element scaling:**It is not clear to us How RAN4 should start to work on the “antenna element scaling”. As MTK already mentioned, the current antenna element number is up to implementation, and be transparent to the spec. **For UE/cell specific Pmax and power control tolerance enhancement:** We support the proposal from on “Specify MOP requirements for UE-specific P-Max and cell-specific P-Max limitations” and “enhancement of FR2 power control accuracy requirements”. The large tolerance for power control makes the requirement and test result less meaningful in practice.  |
| vivo | CA related features which is inherited from Rel-16 is generally worthy to be continued in Rel-17.MPE and BC can be considered the coordination with RAN1-led work.MOP requirements (configured output power) for P-Max not needed. |
| Huawei | 1. Inter-band DL CA: we support to further discuss on the CBM RF requirement in Rel-17.
2. Inter-band UL CA: it is based on the operators’ request whether inter-band UL CA is needed. We are open to discuss whether and how CBM and IBM apples to inter-band UL CA.
3. Potential intra-band NC enhancement: More than 3 subblocks in UL may not help on the UL performance enhancement, frequency distortion is complex. We need first study on deployment demand and whether there is performance enhancement.
4. Beam correspondence: beam correspondence requirement targets to verify on the RF performance of UL and DL chain matching. The dynamic radio conditions is not suitable for RF requirement verification.

For Nokia propose, it is not clear.We already receive the reply LS from RAN1 for CSI-RS only BC, it shows most companies are supportive on CSI-RS only scenario, we need to improve BC for CSI-RS only.1. MPE: MPE enhancement is under discussion under RAN1, we need to follow on RAN1 conclusion in Rel-17. The objective has already been included in RAN1-led Rel-17 FeMIMO WID, and thus there would be no need to capture it in FR2 enh.
2. Antenna scaling: in our understanding, antenna scaling is an UE implementation issue for power control, seems such implementation do not have impact on RF requirement definition.
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### Sub-topic 1-2: WI objectives for each identify Rel-17 FR2 RF sub-work area

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| **Company** | **Comments and proposals** |
| Apple | We provide our proposed set of new enhancements for Rel-17 FR2 RF work below:- Beam correspondence enhancement with localized beam sweeping, such that: [RAN4]- The UE relies on the unified TCI framework for DL and UL beam indication- The network configures a small number of SRS resources (e.g. fewer than 8) to improve UE Tx beam selection based on DL RS only- Non-simultaneous uplink (NSU) on inter-band UL CA in FR2 [RAN4]- Define RF requirements for non-simultaneous transmission on aggregated UL carriers with UE switching between non-contiguous carrier groups for the case(s) of inter-band UL CA in FR2- Define RRM requirements for non-simultaneous transmission on aggregated UL carriers with UE switching between non-contiguous carrier groups for the case(s) of inter-band UL CA in FR2- Considering the cases of NSU for carriers which can be a Pcell, Scell, or Pscell in RF and RRM work- FR2 UE antenna element scaling, such that: [RAN4, RAN1]- UE antenna element scaling can occur for Tx only, Rx only, or Tx & Rx arrays- Study the impact of antenna element scaling on UE RF requirements (such as transmit power control tolerance, maximum output power, minimum output power, beam correspondence, and maximum input level) and RRM requirements (such as beam management, UL spatial relation switch, RLM, etc), and, if identified, specify the corresponding requirements [RAN4]- Study the impact of antenna element scaling on the physical layer design associated with beam management, and if identified, specify the corresponding requirements [RAN1]- Study and, if feasible, introduce UE specific and NW configured UL gap for general self-calibration and monitoring purpose, * If feasible, specify UL gap related configuration(s), including but not limited to UL gap periodicity, UL gap length and related RF requirements if necessary [RAN4]
	+ To minimize the impact on UL scheduling and throughput performance, UL gap duty cycle, e.g. UL gap length/UL gap periodicity, should be maintained below [X]%, where X is FFS
	+ During UL gap, UE should either not transmit anything or the related output power is limited by [Y]dBm/MHz, where Y is FFS
* If feasible, introduce UL gap related gap configuration in TS38.133 and UE signaling in RAN2 spec (RAN2/4)
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| Qualcomm | We provide our comments to the Apple proposals below:Beam correspondence enhancements: If this about defining requirements for a RAN1 item then it should be handled under that specific item and not in a RAN4 item. If this is not the case then we would like to better understand what is the issue that we are trying to solve. It seems very difficult to define requirements for this kind of optimization with a black box testing approach given the current vague descriptionNSU on inter-band UL CA The system gains from this scheme are not clear. FR2 is a system in which UEs are TDM-ed, not FDM-ed. This switching schemes seems to be useful for load balancing, however load balancing in FR2 is not needed because the UEs are TDM-ed. FR2 UE antenna scaling The current description is too vague, it is not clear what is the problem we are trying to solve. What in the current specifications is stopping the UE from doing antenna element scaling? UL gaps for self calibration: The objectives should be clarified, and the gain should be clearly specified in the end. We believe that if this work proceeds there should be a study phase in which the performance gain over the current baseline(Rel.16 requirements) should be clearly identified(e.g. power output increase, etc). For the actual work, the amount of performance enhancement(e.g.how many dBs the UE output power can be increased) should be specified under the condition that a certain amount of gaps is available. Our understanding is that the current baseline would be maintained if the UL gaps are not configured by the network.MPE Enhancements The objectives need to be clarified, is there a need for RAN1 involvement or not? |
| LGE | Objectives* Inter-band UL CA
	+ specify inter-band UL CA for two bands including both CBM and IBM
		- Both CBM/IBM RF requirements for peak/spherical EIRP with delta Tib
	+ Non-simultaneous uplink (NSU) on non-contiguous carriers
		- Define RF requirements for TDM operation for non-simultaneous transmission between non-contiguous carrier groups of inter-band UL CA in FR2
		- Define RRM requirements for TDM operation non-simultaneous transmission between non-contiguous carrier groups of inter-band UL CA in FR2
		- Considering the cases of NSU for carriers which can be a Pcell, Scell, or Pscell in RF and RRM work
* Inter-band DL CA
	+ Define UE RF requirements for inter-band CA within the same freq. group (e.g. 28GHz + 28GHz) with CBM as baseline
	+ Define UE RF requirements for inter-band CA between different freq. groups (e.g. 28GHz + 37GHz) with CBM as optional
* MPE enhancements
	+ Define additional UE capability to resolve RLF problems with dynamic duty-cycle mechanism
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| Samsung | NSU on inter-band UL CAThe system performance gain provided by NSU is not clear. When simultaneous UL CA is possible, we do not see the necessity to standardize a lower capability UL CA in terms of non-simultaneous transmission. FR2 UE antenna scalingIn our understanding, UE antenna scaling shall be up to UE implementation. |
| Nokia | Draft objective proposals (for the topics proposed in the Nokia comments in 1-1):* Specify enhanced inter-band DL CA requirements for UE RF and UE RRM for the following cases:
	+ Low-Low and High-High cases
	+ Common Beam Management (CBM)
* Specify Inter-band UL CA UE RF and RRM requirements for two bands for both Common Beam Management (CBM) and Independent Beam Management (IBM)
* Study non-simultaneous UE UL transmission for inter-band UL CA
* Specify enhanced UE beam correspondence requirements (after finalizing remaining TBDs in the Rel-16 requirements)
	+ Study BC requirement and test cases enhancements for dynamic radio conditions (in realistic FR2 deployments conditions vary significantly and it is important to ensure that UEs are able to have and keep good beam correspondence)
* Study UE MPE enhancements for beam management and mobility enhancement purposes e.g. study introduction of UE’s MPE related reports to target beams/cells to allow the source gNB to optimize beam management
 |
| Huawei | * Inter-band DL CA
	+ Define UE RF requirements for inter-band CA within the same freq. group (e.g. 28GHz + 28GHz) with both CBM and IBM type.
	+ Define UE RF requirements for inter-band CA between different freq. groups (e.g. 28GHz + 37GHz) with CBM type.
* CSI-RS only beam correspondence with P1 CSI-RS QCL relation configured with ‘none’
* Study and, if feasible, introduce UE specific and NW configured gap for general self-calibration and monitoring purpose.
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### Sub-topic 1-3: Any Other Issues

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| **Company** | **Comments and proposals** |
| Apple | On UL gap proposal, it has been discussed in RRM thread. Companies’ comments are copied and pasted here

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| Company  | Views and comments  |
| Apple | Support |
| CATT | In general we are supportive to have such study for FR2 since the performance of FR2 might be a concern. Need to understand the implication to the current requirements. |
| OPPO | Support. Calibration gap has been discussed and studied since Rel-15 which proved a useful feature from UE’s perspective. It seems straight-forward to further specify this feature for FR2 in Rel-17 in order to enable the feasibility of network and UE implementation. |
| CMCC | We are open to study, and it seems like further enhancement on Rel-15 UL gap related requirements. |
| vivo | Support. This was discussed in R15 but eventually there was no impact to spec. In our view this at least should be further studied in R17. |
| Xiaomi | We are OK to have a study on the feasibility of this topic. |
| MTK | Support. But we suggest to handle this in FR2 RF work area where the motivation of this gap is discussed. RF experts should have better knowledge than RRM experts on when and how frequent this gap is needed. |
| Nokia | RP reference is missing. |
| ZTE | Open to further discuss |
| Ericsson | This was extensively discussed in Rel-15 in RF session. In our view the conclusion was nothing needs to be specified. We agree with MTK this is RF issue and the need to again open this issue in Rel-17 should be discussed in RF FR2 thread. This should not be discussed in this (RRM thread) because calibration issue is not within RRM scope/competence.  |

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| Qualcomm | The benefit of this feature should be discussed in this thread, in our view. RRM session only discussed whether the switching mechanism an be specified or not, in our understanding. |
| Nokia | Like Qualcomm we also see that the benefits and motivation of the feature proposal should be discussed under FR2 RF like discussed in Rel-15 |
| Huawei | We support this idea. In our view, such gap or period is useful in terms of improving the FR2 performance.The proposal seems related to the gap. Gap is usually specified for measurement or the BS scheduling restriction requirement will be specified for such period without transmission. And during the discussion for gap or for other RRM requirement, the RF impact would also be discussed. So from our perspective, it would be OK to treat this topic in RRM WID by involving RF delegate  |
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## Summary of discussion

Companies are supportive to continue UE FR2 RF work in Rel-17. Number of proposals were made but the scope should be rather limited due to e-meeting arrangements.

# Conclusions

Proposal for the objectives considering available TUs and RAN4 workload.

The purpose of this work item is to specify the following FR2 UE features and associated requirements:

* Inter-band DL CA enhancements [RAN4 RF/RRM]
	+ - Define UE RF requirements for common Beam Management (CBM) between different freq. groups (e.g. 28GHz + 37GHz) based on explicitly requested band combinations.
		- Define UE RF requirements for inter-band CA within the same freq. group (e.g. 28GHz + 28GHz) for CBM and independent beam management (IBM) based on explicitly requested band combinations.
		- Including RF and RRM requirement aspects
* Inter-band UL CA [RAN4 RF/RRM], on hold until there is operator request for uplink CA configuration in Basket WI
	+ - specify inter-band UL CA for two bands for CBM and IBM based on explicitly requested band combinations
		- study on non-simultaneous UL for inter-band
* Beam Correspondence enhancements [RAN4 RF/RRM, RAN2?]
	+ - CSI-RS based beam correspondence with P1 CSI-RS QCL relation configured with ‘none’
		- Further enhancements for beam correspondence when network signal is poor
		- Study BC enhancements and requirements for dynamic radio conditions, including localized beam sweep enhancement based on unified TCI framework for DL and UL beam indication specified in Rel-17 FeMIMO WI
		- Beam Correspondence enhancements for initial access i.e. based on SSB and based on PRACH power control
* UL gaps for self-calibration. [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) and associated UL gap configuration (e.g. power output increase, etc).
		- Phase 2: Specify the UL gap configuration(s) 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

# References

[1] RP-201109, Views on Rel-17 RAN4 RF work plan, Apple Inc.

[2] RP-201331, Work areas of RAN4 R17 non-spectrum related WI/Sis, RAN4 Chairman (FUTUREWEI)