**3GPP TSG-RAN WG4 Meeting # 104bis-e R4-22xxx**

**Electronic Meeting, 10-19 October 2022**

**Agenda item:** 6.18.5

**Source:** Moderator (Ericsson)

**Title:** Email discussion summary for [104-bis-e][220] FS\_NR\_pos\_enh2\_RRM

**Document for:** Information

# Introduction

The document contains discussion related to the positioning measurement requirements. The document contains the following 2 main topics:

• Topic #1: PRS/SRS bandwidth aggregation for intra-band carriers (AI: 6.18.4)

• Topic #2: NR carrier phase measurements (AI: 6.18.4)

Delegates commenting on this topic are requested to add their contact information in the table below.

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Note:

1. Please add your contact information in above table once you make comments on this email thread.
2. If multiple delegates from the same company make comments on single email thread, please add you name as suffix after company name when make comments i.e. Company A (XX, XX)

# Topic #1: PRS/SRS Bandwidth Aggregation for Intra-band Carriers

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2215432**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215432.zip) | CATT | **Proposal 1: Some simulations are needed to evaluate the impact of timing and frequency offset.** **Proposal 2: RAN4 assumes that one FFT processing per CC as baseline but the FFT size assumption can be further checked by simulation.** **Proposal 3: Wait for RAN1 conclusion or RAN1 LS to start RAN4 work on accuracy improvement study based on carrier phase measurements.**  |
| [**R4-2215825**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215825.zip) | OPPO | **Observation-1: The MRTD/MTTD requirements for intra-band CA is too large to achieve higher positioning accuracy.** **Proposal-1: Study the enhanced MRTD/MTTD requirements to determine the feasibility of PRS/SRS bandwidth aggregation.** |
| [**R4-2215885**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215885.zip) | Ericsson | **Proposal 1**: PRS resources sharing the same numerology across carriers/PFLs can only be aggregated for MC positioning measurements.**Proposal 2**: PRS resources in different carriers/PFLs from the same TRP or co-located TRPs can only be aggregated for MC positioning measurements.**Proposal 3**: PRS resources to be aggregated for MC positioning measurements from different PFLs/carriers can have different bandwidths.**Observation 1**: Number of carriers/frequency layers configured to UE for CA/DC communication can be changed dynamically/semi-statically. Number of activated SCells may also be changed over time**Proposal 4**: Depending on the MCPC capability of UE capability, the LMF will configure the UE with two or more carriers/PFLs for MC positioning measurements.**Proposal 5**: The number of carriers/PFLs with which UE is configured for MC positioning measurement has an impact on MC positioning measurement period.**Observation 2**: The UE may typically fully or partially reuse its RF resources for MC communication for performing MC positioning measurements.**Observation 3**: The LMF which configures UE for performing MC positioning measurements may not be aware of the ongoing CA/DC operation for communication.**Proposal 6**: Evaluate MCPC and its impact on RRM when MC positioning measurement is done within MG. **Proposal 7**: Evaluate MCPC and its impact on RRM when MC positioning measurement is done outside of the MG.  |
| [**R4-2216229**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216229.zip) | Nokia, Nokia Shanghai Bell | 1. For the RRM impacts study, prioritize intra-band contiguous CA with simultaneous PRS or SRS symbols transmitted for the different carriers in the same slot.
2. CA configurations with 2, 3 and 4 CCs should be investigated and the configuration with 2 CCs should be prioritized over 3 and 4 CCs.
3. PRS/SRS bandwidth aggregation should also be investigated for RRC\_INACTIVE.
4. RAN4 to study RRM impacts for PRS/SRS bandwidth aggregation on measurement period requirements, measurement reporting requirements, measurement accuracy requirements as well as additional margins for covering impairments following preferred scenarios, i.e. intra-band contiguous with simultaneous PRS/SRS transmission, preferred number of CC’s, support in connected and inactive RRC states.
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| [**R4-2216685**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104Bis-e/Docs/R4-2216685.zip) | Intel Corporation, CATT, Ericsson | Work Plan for Study Item on Expanded and Improved NR Positioning* *Paper provides tentative work plans for informational purposes*
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## Open issues summary

### Sub-topic 1-1: Conditions/assumptions for PRS/SRS bandwidth aggregation

**Issue 1-1-1: FFT size**

* Proposals
	+ Proposal 1: CATT
		- RAN4 assumes that one FFT processing per CC as baseline but the FFT size assumption can be further checked by simulation
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | This issue is discussed in issue 2-1e: Baseline assumption for FFT processing in the RF thread [138].This is also fundamentally RF related and should be discussed in RF or at least should not be discussed in both threads. |
| Huawei | We understand the FFT size should be an implementation issue. What needs to be specified is the SCS and RB number of each PRS/SRS CC to be aggregated as well as the total BW of aggregated CCs (similar to BW class for data CA). |
| OPPO | Agree that the FFT size is up to Rx implementation.  |
| Intel | For the assumption of one FFT per CC it sounds reasonable when we considering the RAN4 requirements and processing capability. For the FFT size, it is unclear how RAN4 evaluate FFT size impacts. In our views, RAN1 could evaluate such impacts by system level simulation. On the other hand, the FFT size needed will impact the minimum timing estimation resolution because the minimum sampling rate is up to subcarrier spacing and FFT size. |
| Nokia | RF session at the present meeting has agreed to move the FFT size discussion to RRM session. Since RF session also agreed to prioritize single Tx/Rx chain both for BS and UE, we think the study on FFT size including common FFT over the contiguous CCs is needed to identify the impact on measurement accuracy. So, proposal 1 can serve as baseline in regard to UE computational complexity. |
| CATT | As mentioned by Nokia, RF session has agreed the FFT assumption will be discussed in RRM part. We think we need to align the assumption whether common FFT is used for multiple CCs. In our understanding, the legacy assumption for RRM measurement, i.e. one FFT processing per CC should be used. For the FFT size, we understand if we need link simulation to evaluate the performance of PRS aggregation, it should be clarified whether higher FFT size can be used as we did in R17 positioning evaluation. So we think proposal 1 can be the baseline to study the performance gain of aggregation.  |
| Xiaomi |  |
| Qualcomm | Our view is that FFT/IFFT size is an implementation choice. It’s not clear to us how the assumption of single FFT/IFFT would impact the outcome of this study in RAN4. If no clear impact is identified, then perhaps this issue does not need to be discussed further in the study phase. |
| apple | Leave it as UE implementation issue. |
| Ericsson3 | We agree with some of the comments that FFT size assumption is up to UE implementation. The UE implementation should allow both options: single FFT and multiple FFTs (FFT per CC). The possible implication on the requirement to allow different UE implementation flexibility in terms of FFT shall be discussed during WI phase. |

**Issue 1-1-2: Numerology across carriers**

* Proposals
	+ Proposal 1: E///
		- PRS resources sharing the same numerology across carriers/PFLs can only be aggregated for MC positioning measurements
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | Support this proposal. This is fundamental to bandwidth aggregation to enhance positioning measurements, mainly timing/ranging based measurements. |
| Huawei | Support P1  |
| OPPO | Support proposal 1. |
| Intel | We don’t fully understand the purpose to limit the deployments of multiple carrier/PFLs regarding to the different numerology. In Rel16 pos, for RSTD measurement, ToA measurements on the different PFLs (e.g. different numerology) can be aggregated to conduct RSTD also.  |
| Nokia | We support proposal 1. |
| CATT | Could the wording be refined as the following? Only the PRS resources sharing the same numerology across carriers/PFLs can be aggregated.  |
| Xiaomi | Support P1 |
| LGE | Support P1 |
| Qualcomm | P1 seems to be a reasonable assumption for intra-band contiguous layers. We would suggest to clarify the wording a bit:“For PRS bandwidth aggregation, a common numerology is required across all PFLs to be aggregated.” |
| apple | Support P1. No clear benefit to enable mixed numerologies  |

**Issue 1-1-3: Co-location of carriers**

* Proposals
	+ Proposal 1: E///
		- PRS resources in different carriers/PFLs from the same TRP or co-located TRPs can only be aggregated for MC positioning measurements Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | Support this proposal. This is fundamental to bandwidth aggregation to enhance positioning measurements, mainly timing/ranging based measurements. |
| Huawei | Support P1  |
| OPPO | Support proposal 1. |
| Intel | This is fine for us because the non-colocated TRPs may introduce much larger timing offset than co-located which can degraded the positioning preference significantly.  |
| Nokia | We support proposal 1. |
| CATT | Fine with proposal 1.  |
| Xiaomi | Support P1 |
| LGE | Support P1 |
| Qualcomm | We agree that PRS resources to be aggregated should be transmitted by a single TRP but this is not sufficient. PRS resources to be aggregated should be associated with a common Antenna Reference Point (ARP) or with ARPs that are sufficiently close to each other. Single ARP can be the baseline.R4-221210:**Observation 13a: For aggregation of PRS resources from the same TRP across PFLs, if the PRS resources are associated with different ARPs, physical proximity between the ARPs should be considered as a pre-condition for aggregation.** |
| apple | Support proposal 1 |
| Ericsson3 | To Qualcomm: ARP is not used in the specs rather we use TRP in RAN1 and RAN2 specs (LPP) so TRP is sufficient. We understand that antennas should be physically close to each other however the antenna proximity shall not be discussed in RRM because this is not RRM expertise. If needed antenna proximity condition can be discussed as a part of RF session or can be decided by RAN1. |

**Issue 1-1-4: PRS BW of carriers**

* Proposals
	+ Proposal 1: E///
		- PRS resources to be aggregated for MC positioning measurements from different PFLs/carriers can have different bandwidths.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | Support this proposal. PRS resources with different bandwidths can be aggregated for positioning measurements. |
| Huawei | To clarify, based on P1 in Issue 1-1-2, the aggregated PFLs will have same SCS, so here different BW can only be due to different RB numbers. If this is the intention of P1, then we can support it. |
| OPPO | Support proposal 1. |
| Ericsson2 | To Huawei: Yes the understanding is correct. PRS resources that can be aggregated can have different RB numbers but must have same SCS. |
| Intel | This is fine. But we are not sure what the purpose of these proposals (1-1-1, 1-1-2, 1-1-3,1-1-4). Are RAN4 going to forward them to RAN1? |
| Nokia | We support proposal 1. If we study this case of different BW with different RB numbers, we need to define a limited number of scenarios. |
| CATT | Support proposal 1.  |
| Xiaomi | Support P1 |
| LGE | Support P1 |
| Qualcomm | Support P1 |
| apple | We are OK with P1.  |

**Issue 1-1-5: Proximity of carriers in frequency domain**

* Proposals
	+ Proposal 1: Nokia
		- For the RRM impacts study, prioritize intra-band contiguous CA with simultaneous PRS or SRS symbols transmitted for the different carriers in the same slot.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | We support the idea that the multicarrier positioning measurements should be defined for intra-band contiguous CA.  |
| Huawei  | We support to prioritize intra-band contiguous CA which is aligned with RF agreement. As to P1, we suggest the following update to reflect simultaneous PRS/SRS transmission:*For the RRM impacts study, prioritize intra-band contiguous CA with simultaneous PRS or SRS symbols transmitted for the different carriers in the same symbol(s)* |
| OPPO | We understand the intra-band contiguous CA is already agreed in RF session, then proposal 1 is to specify PRS/SRS proximity in the time domain. We prefer Huawei’s proposal to restrict PRS/SRS in the same symbol.  |
| ZTE | From the perspective of delay and the processing gain, we prefer to investigte P1, but we deem that PRS or SRS symbols should be transmitted for different carriers in the same slot. For transmitting in the same symbol(s), this is to be discussed in this meeting.  |
| Intel | We can support P1.  |
| Nokia | We support proposal 1 and it is aligned to the agreement in the RF session. To clarify, we refer to either DL with simultaneous PRS symbols of contiguous carriers in the same slot, or UL with the same for SRS symbols. |
| CATT | Support proposal 1 which is aligned with RF session.  |
| Xiaomi | We are fine with the updated version form Huawei. |
| LGE | We are fine with Huawei’s updated version. |
| Qualcomm | Agree in principle with Huawei’s intention. Suggest further clarification:*For the RRM impacts study, prioritize aggregation of intra-band contiguous PRS or SRS transmitted in different layers/carriers, in the same slot and in the same symbols.* |
| Apple | OK with Qualcomm’s version |

**Issue 1-1-6: Number of carriers**

* Proposals
	+ Proposal 1: Nokia
		- CA configurations with 2, 3 and 4 CCs should be investigated and the configuration with 2 CCs should be prioritized over 3 and 4 CCs.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | Number of CCs will be UE capability. The maximum number of CCs for which requirements are defined can also be decided in WI phase. |
| Huawei | Since it was agreed to prioritize intra-band contiguous CA, we assume the CC number (2, 3 or 4) does not cause difference to the feasibility of PRS/SRS CA as long as single chain Tx/Rx architectures is assumed. We may miss some point here, so it would be good if proponent could clarify the reason to prioritize 2CC case. |
| OPPO | Support proposal 1. |
| ZTE | we support that we should investigate the number of the transmitted CCs, and the values we proposed are [2,3,4], but we need the solid grounds why should we prioritize the 2CCs. |
| Intel | In our views, this is up to RF session discussion.  |
| Qualcomm | Proposal 1 is fine. We’re not sure if it needs to be discussed in RRM. |
| Nokia | We support proposal 1 and it is aligned to the agreement in the RF session. |
| CATT | From RRM perspective, we also think that the number of CCs does not cause much difference for the feasibility.  |
| Xiaomi | Share the similar view as Huawei/ZTE, the further clarification on prioritization of 2CCs is needed from RRM perspective. |
| apple | OK with proposal 1. We can prioritize 2CC to simplify the RF impairment model.  |

### Sub-topic 1-2: Impact of MRTD/MTTD

**Issue 1-2-1: Impact of MRTD/MTTD on PRS/SRS bandwidth aggregation**

* Proposals
	+ Proposal 1: OPPO
		- Study the enhanced MRTD/MTTD requirements to determine the feasibility of PRS/SRS bandwidth aggregation.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson  | MRTD and MTTD are fundamental deployment parameters which exist since Rel-15. MRTD/MTTD requirements cannot be changed. The PRS/SRS bandwidth aggregation has to work in the existing network deployment. We therefore do not see any need to study or modify MRTD/MTTD. |
| Huawei  | For MRTD, it is noted that the existing MRTD is for data CA, and how we define the timing error limit for PRS/SRS CA, e.g. in the form of MRTD or as the side condition for UE requirements, needs to be further discussed. In addition, RF has concluded in last meeting that PRS/SRS CA is feasible with single chain Tx/Rx architectures, and they are discussing the timing error to be considered with the single Tx/Rx chain architecture. It is too early to discuss new MRTD requirement in RRM.For MTTD, if single Tx chain is assumed, the SRS CCs will be all in the same TAG, and there is no need to consider MTTD which is for different TAGs. |
| OPPO | We are not trying to revise MRTD/MTTD for fundamental deployment, but to discuss timing difference requirements for PRS reception or SRS transmission among aggregated carriers. For PRS CA, although RF session confirmed its feasibility with single chain architecture, but the timing error requirements are not determined. If the timing error is larger than the existing error, it is not reasonable to support PRS aggregation.  |
| ZTE | We compromise to discuss the timing error requirements.But it is unnecessary for us to revise MRTD\MTTD or investigate the new MRTD\MTTD. |
| Intel | It is too early to consider the specific RRM requirements. We thought in current SI stage we need not to consider such requirements enhancement  |
| Nokia | RF session at this meeting agreed to investigate the accuracy impact for a range of TAE values between CCs for the single Tx/Rx chain. This can be considered independent from existing MRTD and MTTD requirements.  |
| CATT | We are fine to study the timing difference between different CCs and share the same view as other companies that no need to discuss MRTD/MTTD requirements for now.  |
| Xiaomi | We are fine to study the timing difference between PRS/SRS CCs. |
| LGE | We have similar view with Huawei. |
| Qualcomm | According to issue 1-1-3, transmitter co-location is a pre-condition for PRS aggregation across layers. As we commented issue 1-1-3, the baseline assumption is that PRS resources to be aggregated are associated with a common transmitter ARP. This is consistent with the single Tx/Rx chain architecture that RAN4 has agreed to prioritize in this study. Nominally, there should not be timing offset between layers under this assumption. It is understood that group delay may introduce residual timing error between layers but in our view this would be accounted for with GD margin during the WI phase.Similar comment for SRS assuming single Tx chain.  |
| apple | This is up to RF discussion if TAE can be tightened.  |

### Sub-topic 1-3: Impact of timing and frequency offset on PRS/SRS bandwidth aggregation

**Issue 1-3-1: Timing and frequency offset impact on PRS/SRS bandwidth aggregation**

* Proposals
	+ Proposal 1: CATT
		- Some simulations are needed to evaluate the impact of timing and frequency offset.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | RRM impact is not clear. Proponent is requested to clarify the proposal. In our view the impact of timing and frequency offset depends on the RF architecture i.e., whether single or multiple RX/TX chains are used for PRS/SRS bandwidth aggregation. Therefore, these issues are more relevant for RF discussion under RF thread [138]. |
| Huawei | We understand the impairments including timing and frequency error are being discussed in RF, and we should not repeat the same discussion in RRM. When defining the requirements during potential WI phase, RRM can align the assumption based on the outcome of RF study. |
| ZTE | Agreed with Ericsson, this issue should be discussed after the discussion in RF thread. |
| Intel | These simulations to evaluate the impacts from the TF offset are more like the system level simulations to evaluate the eventual positioning performance given some residual T/F errors. RAN1 should have such evaluation works. RAN4 maybe needs to evaluate the boundary of TF offset in RF session. |
| Nokia | We agree, this is related to RF impairments and will be addressed in RF session. Frequency offset has been down-prioritized in RF session for single Tx/Rx chain both in BS and UE, whilst impact of timing offset, group delay and phase noise for FR2 will be investigated.  |
| CATT | Our initial thinking is to simulate the performance for different timing offsets (e.g. as we discussed in issue 1-1-5 whether the PRS resources are transmitted in the same slot or same symbol) and frequency offsets between CCs to see the gain of PRS aggregation. But we are also fine to investigate the impact in RF session and define the requirements in potential WI stage in RRM session.  |
| Qualcomm | We proposed in our paper R4-2216725 to study the impact of timing and frequency offset for RF architectures other than single Tx/Rx. However, in GTW it was agreed to prioritize single Tx/Rx chain for both BS and UE in this study. Assuming single Tx/Rx chain and common ARP, then we don’t see how these impairments apply with these assumptions. Note that this does not include group delay errors, which would be applicable.We agree that we should avoid duplicating the discussion in two threads. |
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### Sub-topic 1-4: Impact of CA/DC on PRS/SRS bandwidth aggregation

**Issue 1-4-1: Relation between CA/DC and PRS/SRS bandwidth aggregation capabilities**

* Proposals
	+ Proposal 1: E///
		- Depending on the MCPC capability of UE capability, the LMF will configure the UE with two or more carriers/PFLs for MC positioning measurements.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | Support this proposal. UE has limited capability in terms of number of CCs it can measure at a given time. The number of CC(s) configured to UE for CA/DC is dynamic/semi-static and is not known to LMF. It is not certain that the UE can do CA/DC for communication while also perform MC positioning measurements with full capability. Therefore, LMF shall configure UE with two or more carriers/PFLs for MC positioning measurements depending on the current MCPC capability of the UE.  |
| Huawei  | Support P1. |
| OPPO  | Support proposal 1. |
| ZTE | Support proposal 1. |
| Intel | MCPC is depending on the PLFs or carriers number. But such capability need to be defered to the WI stage.  |
| Nokia | RF session agreed to investigate performance for 2, 3 and 4 carriers, Hence proposal 1 is supported. |
| CATT | It is too early to discuss the signaling which should be discussed in WI stage. And if the capability for the number positioning carriers is needed, it should be a different capability with the current CA capability.  |
| Xiaomi | Fine with P1 |
| LGE | Support P1 |
| Qualcomm | Our view is that this will be addressed by RAN1 during the WI phase. Not sure if an agreement is needed in RAN4 at this time. |
| Ericsson3 | We understand that UE may have different MCPC capability and CA capability for communication. However, if both MC positioning measurement and CA operation are going on parallel to each other there might be some implication depending on the configured CA for positioning and communication. LMF has to take this into account while configuring MC positioning measurement. Our understanding is that there should not be any implication on the CA for communication when the UE is configured with MC positioning. |

**Issue 1-4-2: Impact of carriers configured for CA/DC on PRS/SRS bandwidth aggregation**

* Proposals
	+ Proposal 1: E///
		- The number of carriers/PFLs with which UE is configured for MC positioning measurement has an impact on MC positioning measurement period.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | Support this proposal. When a UE is configured to MC positioning measurement from different carriers/PFLs then in principle the PRS measurement period should be independent of the number of CCs used for PRS aggregation because PRS across all the CCs are measured at the same time. However, the MC positioning measurement period may be impacted if the UE is performing CA/DC operation for communication and whether the CCs used for the CA/DC operation are the same or they are different than the CCs used for MC positioning measurement.  |
| Huawei  | We understand it is too early to discuss the impact to measurement period requirements, which should be discussed in WI phase.  |
| OPPO | Agree the measurement period will be impacted. In our understanding, one simple way is to accumulated the measurement period in the term of “aggregated carriers/PFLs”. We are fine to further discuss this issue in WI phase. |
| ZTE | Support P1. |
| Intel | Same as issue 1-4-1. |
| Nokia | RF session agreed to investigate contiguous intra-band carrier aggregation with simultaneous PRS/SRS transmission. Hence, the impact on measurement period requirements depends at least on PRS configuration and UE MCPC capability. |
| CATT | Same view as Huawei that it is too early to discuss the requirements. And it is not clear how to perform the measurement on the aggregated carriers for now.  |
| Xiaomi | Share the same view as Huawei/CATT |
| Qualcomm | Too early to discuss measurement requirements. |
| apple | Can be discussed later. |

### Sub-topic 1-5: Applicable RRC state for PRS/SRS bandwidth aggregation

**Issue 1-5-1: PRS/SRS bandwidth aggregation in RRC\_INACTIVE**

* Proposals
	+ Proposal 1: Nokia
		- PRS/SRS bandwidth aggregation should also be investigated for RRC\_INACTIVE.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | Fine to investigate until the next meeting. |
| Huawei  | Support P1.We do not see feasibility issue from RRM perspective to support PRS/SRS CA in INACTIVE state. It is noted that RRC state mainly relates to whether UE has data to transmit or receive, and it has little to do with positioning requirements. If PRS/SRS CA is not supported in INACTIVE state, it means NW has to keep UE in CONNECTED state for UE to do high accuracy positioning with PRS/SRS CA, which will be very negative to UE power consumption. |
| OPPO | Open to discuss. |
| ZTE | The proponent should provide the connection between the necessity of investigation for PRS\SRS bandwidth aggregation in RRC\_INNACTIVE and the collisions with other reference signals and downlink channels in RRC\_INACTIVE state. We deem that PRS\SRS CA is not supported in RRC\_INACTIVE. |
| Intel | It is up to UE capability. If UE can support the both positioning in RRC\_INACTIVE state and MC |
| Nokia | We support proposal 1 to enable improved positioning support not only for connected mode, similar as for Rel-17. However, connected mode can take preference.  |
| CATT | Fine with proposal 1.  |
| Xiaomi | Fine with proposal 1. |
| LGE | Support P1 |
| Qualcomm | We’re open to discussing any aspects related to feasibility. Other aspects can be postponed to WI phase. |
| apple | This may be related to measurement periodicity. The same as 1-4, it is not urgent to discuss it now. |

### Sub-topic 1-6: RRM requirements for PRS/SRS bandwidth aggregation

**Issue 1-6-1: RRM issues for PRS/SRS bandwidth aggregation**

* Proposals
	+ Proposal 1: Nokia
		- RAN4 to study RRM impacts for PRS/SRS bandwidth aggregation on measurement period requirements, measurement reporting requirements, measurement accuracy requirements as well as additional margins for covering impairments following preferred scenarios, i.e. intra-band contiguous with simultaneous PRS/SRS transmission, preferred number of CC’s, support in connected and inactive RRC states.
	+ Proposal 2: E///
		- Proposal 1A:
			* Evaluate MCPC and its impact on RRM when MC positioning measurement is done within MG.
		- Proposal 1 B:
			* Evaluate MCPC and its impact on RRM when MC positioning measurement is done outside of the MG.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | P1 together with P1A and P1B in P2 are fine. Both proposals are relevant to evaluate MC positioning RRM impact.  |
| Huawei | For P1, we understand it is related to detailed requirements, and it should be discussed in the WI rather than the SI phase. For P2, we agree that both PRS measurement outside MG and within MG should be considered for PRS CA. The exact impact of MCPC on requirements can be discussed during WI phase. |
| ZTE | Open to discuss. |
| Intel | No need discussion in SI stage. We believe this new aspects will impact the current RRM requirements in high level. But what are these impacts can be postponed to WI stage. |
| Nokia | Based on agreements in the RF session on number of aggregated carriers (2 to 4), we support proposal 1, proposal 1A and proposal 1B. |
| CATT | Same view as Huawei and Intel that the impact on requirements should be discussed in WI stage.  |
| Xiaomi | Same view as Huawei/Intel/CATT, the detail requirements should be discussed in WI stage. |
| Qualcomm | Similar comment as for issue 1-5-1. Issues that impact feasibility can be discussed in the study phase. |
| apple | Agree with others that this can be discussed at WI stage. |
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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 #1-1** | **Issue 1-1-1: FFT size***Tentative agreements:** FFT/IFFT size is up to UE implementation.
* Multicarrier (MC) positioning requirements should allow UE implementation flexibility i.e. single FFT/IFFT or multiple FFTs/IFFTs (i.e. FFT/IFFT per PFL) implementations.
* Impact of UE implementation flexibility in terms of FFT/IFFT on MC positioning requirements shall be discussed during the WI phase.

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic #1-1** | **Issue 1-1-2: Numerology across carriers***Tentative agreements:** For PRS bandwidth aggregation, a common numerology is required across all intra-band contiguous PFLs to be aggregated.

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic #1-1** | **Issue 1-1-3: Co-location of carriers** *Tentative agreements:** *PRS resources in different PFLs to be aggregated for MC positioning measurements, shall be transmitted by the same TRP or by the co-located TRPs.*
	+ *If PRS resources in different PFLs are transmitted from different antennas, then the antennas shall be physical close to each other.*
		- *The condition on physical proximity between antennas is beyond the scope of RRM.*

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic #1-1** | **Issue 1-1-4: PRS BW of carriers** *Tentative agreements:** *PRS resources to be aggregated for MC positioning measurements from different PFLs can have different bandwidths (i.e. different number of PRS RBs).*

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic #1-1** | **Issue 1-1-5: Proximity of carriers in frequency domain** *Tentative agreements:** *To study the RRM impact, prioritize the aggregation of PRS or SRS transmitted in the same slot and in the same symbols from the intra-band contiguous PFLs.*

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic #1-1** | **Issue 1-1-6: Number of carriers** *Tentative agreements:** *Number of intra-band contiguous PFLs for the aggregation of PRS or SRS is up to RF agreements.*
* *To study the RRM impact, number of PFLs is FFS:*
	+ *Option 1: prioritize 2 PFLs*
	+ *Option 2: follow number of PFLs agreed in RF session*

*Recommendations for 2nd round:* Discuss number of PFLs for RRM impact analysis |
| **Sub-topic #1-2** | **Issue 1-2-1: Impact of MRTD/MTTD on PRS/SRS bandwidth aggregation** *Tentative agreements:** *RRM impact of possible timing error between PRS/SRS from different PFLs in single RF chain (Tx/Rx) architecture if defined by RF group will be considered in MC positioning requirements during the WI.*
* *No further discussion needed on impact of existing MRTD/MTTD on MC positioning measurement.*

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic #1-3** | **Issue 1-3-1: Timing and frequency offset impact on PRS/SRS bandwidth aggregation** *Tentative agreements:** *RRM impact of possible frequency offset between PRS/SRS from different PFLs in single RF chain (Tx/Rx) architecture if defined by RF group will be considered in MC positioning requirements during the WI.*
* *RRM impact of possible timing error/offset is covered under issue 1-2-1.*

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic #1-4** | **Issue 1-4-1: Relation between CA/DC and PRS/SRS bandwidth aggregation capabilities** *Tentative agreements:** *Multicarrier positioning capability (MCPC) (e.g. number of intra-band contiguous PFLs) is to be defined during the WI.*
* *FFS: impact of MC positioning measurement on the carrier aggregation for communication when both are configured in parallel.*

*Recommendations for 2nd round:* Further discuss 2nd bullet  |
| **Sub-topic #1-4** | **Issue 1-4-2: Impact of carriers configured for CA/DC on PRS/SRS bandwidth aggregation** *Tentative agreements:** *The impact of number of PFLs configured for MC positioning measurement on the PRS measurement period shall be part of WI.*

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic #1-5** | **Issue 1-5-1: PRS/SRS bandwidth aggregation in RRC\_INACTIVE** *Tentative agreements:** PRS/SRS bandwidth aggregation can be support in RRC\_INACTIVE subject to UE capability.
	+ MC positioning requirements in RRC\_INACTIVE shall be part of the WI.
	+ Any issue related to the feasibility can be discussed during the SI.

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic #1-6** | **Issue 1-6-1: RRM issues for PRS/SRS bandwidth aggregation***Tentative agreements:** MC positioning requirements including PRS measurement period/reporting/accuracy (including margins) etc, shall be part of the WI.
* MC positioning requirements shall be defined with and without measurement gaps.
	+ The corresponding requirements shall be part of the WI.

*Recommendations for 2nd round:* No further discussion |

## Discussion on 2nd round (if applicable)

### Sub-topic 1-1: Conditions/assumptions for PRS/SRS bandwidth aggregation

**Issue 1-1-6: Number of carriers**

* To study the RRM impact, how many PFLs should be considered:
	+ Option 1: prioritize 2 PFLs
	+ Option 2: follow number of PFLs agreed in RF session

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| **Company** | **Comments** |
| Ericsson | Option 2. Follow number of PLFs agreed in RF session. For RRM study there is no need to limit the number of PFLs below what has been agreed in the RF session. It is even better to consider all the PLFs for RRM to study if there is any feasibility issue from RRM perspective.  |
| Intel | We can support Option 2. As we mentioned in GTW, from RRM perspective, we didn’t see any issues to support >1 PFLs as in Rel16. But if there is any feasibility issues raised from RF side, we can follow their conclusions.  |
| Qualcomm | Option 2 |
| CATT | Fine with option 2. But as we have already reached agreement in RF session, we think we may not need any further conclusions here as there is no need to limit the number of PFLs from RRM perspective. So all the PFLs can be included in the RRM study.  |
| Xiaomi | Option 2 |
| OPPO | Fine with option 2. |
| Huawei  | Support option 2.For the SI, the feasibility to support 2 or more than 2 PFLs should come from RF, as other companies also mentioned. During the potential WI, we can discuss in RRM whether we should prioritize the 2 PLFs when defining the requirements.  |
| apple | we are OK with option 2, even though it may not be a bad idea to take 2 PFL as the starting point during the study phase.  |
| Nokia  | We support option 2. We agree with CATT, RF session (stream#138) has got agreement to consider 2 to 4 PFL’s and priority will be on 2 PFL’s. Agreement (GTW session - October 11th)* CA configurations with 2, 3 and 4 CCs should be investigated and the configuration with 2 CCs should be prioritized over 3 and 4 CCs.
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### Sub-topic 1-4: Impact of CA/DC on PRS/SRS bandwidth aggregation

**Issue 1-4-1: Relation between CA/DC and PRS/SRS bandwidth aggregation capabilities**

* Will there be any impact of MC positioning measurement on the carrier aggregation for communication when both are configured in parallel? In either case, please provide your views:

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| **Company** | **Comments** |
| Ericsson | In our view MC positioning measurement should not have any implication on CA/DC for communication. If both MC positioning measurement and CA/DC operation are going on in parallel to each other, in our view there might be some implication depending on how UE is configured for MC positioning measurement and CA for communication. For example, the UE may not be able to perform both MC positioning measurements and CA/DC operation for communication with full capability (max CCs supported by the UE) in the same band. In such situation some temporary capability restriction might be needed depending on number of PFLs used for MC positioning measurement and number of CCs used for CA/DC. In our view there should be no restriction on the CA/DC. Rather number of PFLs for MC positioning measurement should be reduced below its capability if the UE cannot do both operations with full capabilities. Therefore, LMF has to take this into account while configuring the UE for MC positioning measurement. We agree that signaling related to capability etc. should be discussed and specified during the WI. However, impact of the MC positioning measurements and CA/DC operation for communication should be investigated in the SI. |
| Intel | We agree the feasibility can be studied in SI. But it seems in our understanding so far there is no any feasibility issues from RRM perspective. And on the other hand whether and how to introduce the support capability and necessary requirements shall be deferred to WI.  |
| Qualcomm | In general, we do expect restrictions on concurrency between DL-PRS measurements and reception of other DL signals/channels. That is already the case in Rel-16/17 NR positioning, for both measurements within measurement gaps and outside measurement gaps. How the existing restrictions will be adapted/extended to PRS aggregation may depend significantly on new UE capabilities introduced by RAN1 during the WI phase. |
| CATT | We think MC positioning measurement should not impact the carrier aggregation for communication. But whether they can be configured in parallel and how to handle the different UE capabilities of supported number of carriers should actually be discussed in WI stage as requirements. At least for now, this should not be the block for the feasibility of PRS/SRS bandwidth aggregation.  |
| MTK | At least we see no impact when the measurements are performed within measurement gap, in which all data scheduling is suspended. The outside MG case can be FFS. It may also depend on some RAN1 discussions. |
| Xiaomi | In general, we also think the limitation is needed if the MC position measurement and carrier aggregation for communication are configured in parallel. How to define/resolve this issue may depends on the UE capability which should be discussed in WI phase. |
| OPPO | We agree that there are some impacts on CA/DC communications, especially for PRS measurement outside gap and SRS transmission, UE capability and switching time should be discussed. And, this can be discussed in WI phase.  |
| Huawei  | We think it may be too early to discuss this issue in SI. We understand before discussing whether CA/DC would impact PRS CA capability, we first need to know how the UE capability for PRS CA will look like, and that will be defined by RAN1 (maybe based on inputs from RF). In addition, this issue seems not impact the general feasibility of PRS CA.  |
| Ericsson2 | The restrictions due to concurrency between MCPC measurements and CA/DC is mainly for the case when MCPC is performed outside gaps. Even though MCPC measurements should be feasible, but the restrictions will be needed and in our view the CA/DC should not be impacted. The impact of MCPC positioning measurement is more severe on CA/DC than legacy single carrier measurement because in former case the UE is operating more carriers in parallel. Even though these details are for the WI, but this is an important finding under the SI.  |
| apple | I am not sure if I fully understand the question. Firstly, PRS can be only configured on the activated CC. That means MC positioning is only possible with CA.Regarding the impact, there are many aspects to be considered including mobility, throughput etc. it is not an easy question to conclude now.  |
| Nokia | We agree with other companies the impact from PRS/SRS BW aggregation on CA/DC for communication does not affect the feasibility of PRS/SRS BW aggregation from RRM perspective, so this should be further investigated in the WI phase. |

### Sub-topic 1-7: Tentative work plan

**Issue 1-7-1: Tentative work plan**

* R4-2216685 provides tentative work plan for information purpose. It is originally submitted and discussed under thread [104-bis-e][138] FS\_NR\_pos\_UERF. Please provide your feedback if any:

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| **Company** | **Comments** |
| Intel | We are fine with this WP for all WGs |
| CATT | As commented in RF session, we are fine with the work plan.  |
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# Topic #2: NR Carrier Phase Measurements

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2215432**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215432.zip) | CATT | **Proposal 3: Wait for RAN1 conclusion or RAN1 LS to start RAN4 work on accuracy improvement study based on carrier phase measurements.**  |
| [**R4-2215825**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215825.zip) | OPPO | **Proposal-2: Not start the work on carrier phase measurement in RAN4 before progressive conclusions reached in RAN1.** |
| [**R4-2215885**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2215885.zip) | Ericsson | **Observation 4**: Aspects related to reference signal to be used and physical layer procedures for carrier phase measurement are yet to be settled in RAN1. **Observation 5**: Re-using Rel. 17 NR PRS would imply reusing Rel. 17 NR positioning physical layer procedure for carrier phase measurement-based positioning with no significant impact on RRM.**Observation 6**: If a new dedicated reference signal is defined for carrier phase measurement, this would imply a new physical layer procedure and might have an impact on RRM.**Observation 7**: It is not clear whether carrier phase measurement-based technique is going to be defined as a standalone positioning method or is going to be implemented complementary to Rel. 17 positioning methods. **Proposal 8**: RAN4 to wait for RAN1 conclusions on reference signal and physical layer procedure related to carrier phase measurement before evaluating impact on RRM. |
| [**R4-2216229**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104bis-e/Docs/R4-2216229.zip) | Nokia, Nokia Shanghai Bell | 1. For the RRM impacts study, prioritize single carrier PRS/SRS transmission.
2. Carrier phase measurements should also be investigated for RRC\_INACTIVE.
3. RAN4 to study RRM impacts, based on existing and further RAN1 agreements, for carrier phase measurements on measurement period requirements, measurement reporting requirements, measurement accuracy requirements as well as additional margins for covering impairments following preferred scenarios, i.e. single carrier PRS or SRS transmission, support in connected and inactive RRC states.
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## Open issues summary

### Sub-topic 2-1: RAN4 study on carrier phase measurements

**Issue 2-1-1: When to initiate RAN4 study carrier phase measurements?**

* Proposals
	+ Proposal 1: CATT, OPPO, Ericsson
		- RAN4 wait for conclusive RAN1 outcome on carrier phase measurements before starting RAN4 study:
		- Proposal 1A: CATT
			* Wait for RAN1 conclusion or RAN1 LS to start RAN4 work on accuracy improvement study based on carrier phase measurements.
		- Proposal 1B: OPPO
			* Not start the work on carrier phase measurement in RAN4 before progressive conclusions reached in RAN1.
		- Proposal 1C: Ericsson
			* RAN4 to wait for RAN1 conclusions on reference signal and physical layer procedure related to carrier phase measurement before evaluating impact on RRM.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | Support P1. At least an initial conclusion from the RAN1 is needed for RAN4 to evaluate impact of carrier phase measurement on RRM. Until then we suggest to put the RAN4 work on hold. |
| Huawei  | We support P1, and perhaps it is better to first clarify whether RRM needs to be involved in the study for carrier phase positioning.Based on outcome from RAN1 August meeting, RAN1 has agreed on the modeling of all errors for the carrier phase positioning. We are not sure what would be the scope of study from RRM perspective, considering that defining requirements carrier phase measurement would be a work during WI phase. We are open to hear other views.  |
| OPPO | Support proposal 1. |
| Nokia | In our view, RAN4 can start discussion on the evaluation methodology and evaluation framework for carrier phase measurements, in order to evaluate the impact to measurement procedures including measurement accuracy, while RAN1 is concluding the work on reference signals and physical layer procedure. Such approach is also needed due to the tight time schedule of the study.Hence, assumptions on PRS BW, SCS, FR, SNR, propagation channels, FFT size, discussion on modelling of error sources, as identified by RAN1, as well as on evaluation metrics, such as time measurement accuracy, by means of link level simulation, aligned to what has been done for NR positioning Rel-16 and Rel-17 can take place. We also propose to align assumptions / evaluation metrics as much as possible to those for PRS/SRS BW aggregation. |
| CATT | Support proposal 1/1A. RAN1 is still working on the evaluation of carrier phase positioning, it is not clear whether and what the work is in RAN4. More outcomes from RAN1 are needed.  |
| Xiaomi | Support proposal 1, we share the similar view as Huawei, we need to clarify whether RRM requirement should be involved in the study phase for carrier phase measurement. |
| Qualcomm | Support Proposal 1. We agree that at this point there is no clear scope in RRM. |
| apple | Support proposal 1 |
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### Sub-topic 2-2: Conditions/assumptions for carrier phase measurements

**Issue 2-2-1: Number of carriers**

* Proposals
	+ Proposal 1: Nokia
		- For the RRM impacts study, prioritize single carrier PRS/SRS transmission.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | Similar to issue 2-1-1. For RAN4 to evaluate RRM impact at least an initial conclusion on physical layer procedure is needed from RAN1.  |
| Huawei | Support P1.  |
| Nokia | We support proposal 1 and it is part of the afore mentioned evaluation framework. |
| CATT | Similar as issue 2-1-1.  |
| Xiaomi | Need more RAN1 inputs. |
| Qualcomm | See comment for issue 2-1-1. |
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### Sub-topic 2-3: Applicable RRC state for carrier phase measurements

**Issue 2-3-1: Carrier phase measurements in RRC\_INACTIVE**

* Proposals
	+ Proposal 1: Nokia
		- Carrier phase measurements should also be investigated for RRC\_INACTIVE.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | Comments to issues 2-1-1 and 2-2-1 also apply here. |
| Huawei  | Support P1.We understand carrier phase measurement is no different from other positioning measurement like RSTD or PRS-RSRP, and it should be by default supported in all relevant RRC states. |
| Nokia | Agree with Huawei. In order to enable improved positioning support not only for connected mode, similar as for Rel-17, RAN4 should agree on proposal 1. However, connected mode can take preference. |
| CATT | As commented in issue 2-1-1, we think RAN1 outcomes are needed although we are generally fine with the principle in proposal 1.  |
| Xiaomi | Need more RAN1 inputs. |
| Qualcomm | See comment for issue 2-1-1. |
| apple | Agree with Huawei that the carrier phase measurement is not dependent on the RRC states. |
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### Sub-topic 2-4: RRM requirements for carrier phase measurements

**Issue 2-4-1: RRM issues for carrier phase measurements**

* Proposals
	+ Proposal 1: Nokia
		- RAN4 to study RRM impacts, based on existing and further RAN1 agreements, for carrier phase measurements on measurement period requirements, measurement reporting requirements, measurement accuracy requirements as well as additional margins for covering impairments following preferred scenarios, i.e. single carrier PRS or SRS transmission, support in connected and inactive RRC states.
* Recommended WF
	+ Discussion needed

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| **Company** | **Comments** |
| Ericsson | Similar to issues 2-1-1, 2-2-1, and 2-3-1, in our view RAN4 shall wait for at least initial conclusions from ongoing RAN1 evaluation. RAN4 cannot study these aspects unless RAN1 has agreed with the definition and basic framework of the carrier phase measurement. |
| Huawei  | We understand P1 is related to detailed requirements, and it should be discussed in the WI rather than the SI phase.  |
| Nokia | We support proposal 1. To Huawei: we agree, the focus of the study in RAN4 lies on achievable measurement accuracy, hence performance, with some basic assumptions on the measurement parameters and measurement procedure. Details are left to the WI phase. |
| CATT | It is too early to discuss the requirements which should be discussed in WI stage.  |
| Xiaomi | Share the similar view as other companies, the detail requirements should be discussed in WI stage. |
| Qualcomm | See comment for issue 2-1-1. |
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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#2-1** | **Issue 2-1-1: When to initiate RAN4 study carrier phase measurements?***Tentative agreements:** RAN4 wait for conclusive RAN1 outcome on carrier phase measurements before starting RAN4 feasibility study on carrier phase measurement aspects

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic#2-2** | **Issue 2-2-1: Number of carriers***Tentative agreements:** If carrier phase measurement is considered feasible based on RAN1 outcome, then further discuss if single carrier PRS/SRS transmission can be prioritized for the RRM impact study.

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic#2-3** | **Issue 2-3-1: Carrier phase measurements in RRC\_INACTIVE***Tentative agreements:** If carrier phase measurement is considered feasible based on RAN1 outcome, then further investigate if carrier phase measurement is also supported in RRC\_INACTIVE.

*Recommendations for 2nd round:* No further discussion |
| **Sub-topic#2-4** | **Issue 2-4-1: RRM issues for carrier phase measurements***Tentative agreements:** If carrier phase measurement is considered feasible based on RAN1 and RAN4 outcome, then carrier phase positioning measurement requirements including measurement period/reporting/accuracy (including margins) etc, shall be part of the WI.

*Recommendations for 2nd round:* No further discussion |

## Discussion on 2nd round (if applicable)

No discussion on Topic # 2 during the 2nd round.

# Recommendations for Tdocs

## 1st round

**New tdocs**

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| --- | --- | --- | --- |
| **New Tdoc number** | **Title** | **Source** | **Comments** |
|  | WF on Improved NR Positioning  | Ericsson | WF to capture all the agreements |
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**Existing tdocs**

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| **Tdoc number** | **Revised to** | **Title** | **Source** | **Recommendation**  | **Comments** |
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Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics incl. existing and new tdocs.
2. For the Recommendation column please include one of the following:
	1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
	2. Other documents: Agreeable, Revised, Noted
3. For new LS documents, please include information on To/Cc WGs in the comments column
4. Do not include hyper-links in the documents

## 2nd round

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| **Tdoc number** | **Revised to** | **Title** | **Source** | **Recommendation**  | **Comments** |
| R4-22xxxxx |  | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-22xxxxx |  | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-22xxxxx |  | LS on … | ZZZ | Agreeable, Revised, Noted |  |
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Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics.
2. For the Recommendation column please include one of the following:
	1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
	2. Other documents: Agreeable, Revised, Noted
3. Do not include hyper-links in the documents