**3GPP TSG-RAN WG4 Meeting # 106-bis-e R4-2306300**

**Electronic Meeting, 17 April – 26 April, 2023**

**Agenda item:** 5.23.4

**Source:** Moderator (Intel Corporation)

**Title:** Topic summary for [106-bis-e][138] NR\_pos\_enh2\_UERF

**Document for:** Information

# Introduction

*This document captures RAN4 discussions on general aspects and RF requirements for the Rel-18 Expanded and Improved NR positioning work item. Covered agenda items include: 5.23, 5.23.1, and 5.23.2.*

# Topic #1: General aspects and work plan (AI 5.23.1)

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2304440](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2304440.zip)  Discussion on UE RF impact and the reply LS on switching time for RedCap UEs | CATT | *PRS/SRS bandwidth aggregation*  **Proposal 1:** No dedicated or separate RF impairment modelling discussion is needed in WI phase for the solutions based on PRS/SRS bandwidth aggregation unless it’s triggered by RAN1 LS.  **Proposal 2:** No new UE RF requirement is needed for the solutions based on PRS / SRS bandwidth aggregation.  *Carrier phase positioning*  **Proposal 3:** No dedicated or separate RF impairment modelling discussion is needed in WI phase for the solutions based on carrier phase positioning unless it’s triggered by RAN1 LS.  **Proposal 4:** No new UE RF requirement is needed for the solutions based on carrier phase positioning. |
| [R4-2305687](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2305687.zip)  General aspects for Rel-18 NR positioning | Nokia, Nokia Shanghai Bell | **Proposal 1:** RAN4 to discuss how to capture RF impairment models for NR CPP in 3GPP TS or TR. A corresponding revision of the WID may be needed.  **Proposal 2:** RAN4 to carry out the work on RF performance impacts and RF impairment modelling for NR CPP during the core part of the work item.  **Proposal 3:** Take into account the work related to RF impairments modelling for NR CPP in the work plan.  **Proposal 4:** RAN4 to add the modelling of RF impairments for BW aggregation in a new Annex of the same TS/TR as used for NR CPP. A corresponding revision of the WID may be needed.  **Proposal 5:** RAN4 to carry out the work on RF performance impacts and RF impairment modelling for BW aggregation during the core part of the work item.  **Proposal 6:** RAN4 to add RF performance characterization for frequency hopping introduced for RedCap positioning in a new Annex of the same TS/TR as used for accuracy improvements. A corresponding revision of the WID may be needed.  **Proposal 7:** No impact to BS RF requirements is foreseen due to the work on expanded and improved NR positioning. The scope of requirements will be limited to RRM. |

## Open issues summary

### Sub-topic 1-1: Discussion scope and work plan

*Discussions in RAN4 #106 focused on assessing relevant RF scope for the WI objectives. Agreed scope was captured in the approved work plan (R4-2303569).*

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| **RAN4 Meeting** | **Tentative Work Plan** |
| **RAN4#106Bis-e** April 2023  RF TUs: 0.5 | **RF**   * PRS/SRS bandwidth aggregation   + Consider conclusions in TR 38.859 and further discuss potential RF requirement impact and impairment modelling, if needed   + Handle any incoming LS from RAN1 * Carrier phase positioning   + Discuss findings of the RAN1 study on carrier phase positioning and identify potential impact to RF requirements, if any     - If needed, send LS to RAN1 * RedCap UE positioning   + Discuss RF considerations for frequency hopping based DL PRS reception and SRS for positioning transmissions for RedCap positioning, including handling any incoming LS from RAN1 |

**Issue 1-1a: PRS/SRS bandwidth aggregation scope**

* Proposals
  + Option 1: RAN4 to add the modelling of RF impairments for BW aggregation in a new Annex of the same TS/TR as used for NR CPP. A corresponding revision of the WID may be needed. (Nokia, R4-2305687)
  + Option 2: RAN4 to carry out the work on RF performance impacts and RF impairment modelling for BW aggregation during the core part of the work item. (Nokia, R4-2305687)
  + Option 3: No dedicated or separate RF impairment modelling discussion is needed in WI phase for the solutions based on PRS/SRS bandwidth aggregation unless it’s triggered by RAN1 LS. (CATT, R4-2304440)
* Recommended WF
  + Companies are encouraged to share their views on the above options, particularly whether the RF impairment modelling discussion is needed in RAN4 at this time or if it should be triggered by an LS from RAN1.

*Way Forward for carrier phase positioning (R4-2303570):*

* *Consider conclusions of RAN1’s study (TR 38.859) and further discuss RF impairment modelling, if needed*
* *Identify and discuss RF requirement impact (if any)*

**Issue 1-1b: Carrier phase positioning scope**

* Proposals
  + Option 1: RAN4 to discuss how to capture RF impairment models for NR CPP in 3GPP TS or TR. A corresponding revision of the WID may be needed.
  + Option 2: RAN4 to carry out the work on RF performance impacts and RF impairment modelling for NR CPP during the core part of the work item.
  + Option 3: Take into account the work related to RF impairments modelling for NR CPP in the work plan.
  + Option 4: No dedicated or separate RF impairment modelling discussion is needed in WI phase for the solutions based on carrier phase positioning unless it’s triggered by RAN1 LS. (CATT, R4-2304440)
* Recommended WF
  + Companies are invited to comment on the proposed options and should consider if RF impairment discussions are needed at this time

**Issue 1-1c: RedCap UE positioning scope**

* Proposals (Nokia, R4-2305687)
  + Option 1: RAN4 to add RF performance characterization for frequency hopping introduced for RedCap positioning in a new Annex of the same TS/TR as used for accuracy improvements. A corresponding revision of the WID may be needed.
* Recommended WF
  + Address and discuss RAN1 LS first (under [**Sub-topic 2-3**](#_Sub-topic_2-3:_RedCap)). If needed, relevant conclusions of this discussion can be captured in the TR.

**Issue 1-1d: General RF scope - BS**

* Proposals (Nokia, R4-2305687)
  + Option 1: No impact to BS RF requirements is foreseen due to the work on expanded and improved NR positioning. The scope of requirements will be limited to RRM.
* Recommended WF
  + Companies should address whether no impact is expected for BS RF

## Companies views’ collection for 1st round

### Open issues

Sub-topic 1-1a: PRS/SRS bandwidth aggregation scope

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| **Company** | **Comments** |
| Ericsson | Option 3. Maybe we should focus on the objective in WI first. LS from RAN1 may be needed if additional work should be done. |
| Nokia | In our view, options 1 and 2 will allow to better take into account RF impairments for this work based on the architecture assumptions for PRS/SRS BW aggregation in the feasibility study. In particular, the impact to timing measurement types such as RSTD, UE Rx-Tx time difference and gNB Rx-Tx time difference should be studied including impairments modelling in regard to measurement performance requirements. |
| Qualcomm | In our view, the agreements reached in RAN4#106, which are reflected in the Work Plan, are sufficient. |
| CATT | Option 3. Agree with Ericsson that if RAN1 LS is sent to RAN4 to request further work, then they can be done. |
| Intel | Option 3 is ok.  As captured in the work plan, this may be done if needed |
| Huawei | Option 3. Echo Ericsson and Qualcomm’s view, the trigger by RAN1 LS is required if additional work is to be included in Rel-18 positioning for RF session. |

Sub-topic 1-1b: Carrier phase positioning scope

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| **Company** | **Comments** |
| Ericsson | Option 4. Maybe we should focus on the objective in WI first. LS from RAN1 may be needed if additional work should be done. |
| Nokia | In our view, options 1, 2 and 3 will allow to better take into account RF impairments for this work following up on the RAN1 models in the feasibility study TR. In particular, the impact to carrier phase measurement types such as RSCP and/or RSCPD should be studied including impairments modelling in regard to measurement performance requirements. |
| Qualcomm | In our view, the agreements reached in RAN4#106, which are reflected in the Work Plan, are sufficient. |
| CATT | Option 4. Same comment as above issue. |
| Intel | We are ok with Option 4 |
| Huawei | Option 4. |

Sub-topic 1-1c: RedCap UE positioning scope

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| **Company** | **Comments** |
| Ericsson | The LS reply discussion is in scope, but isn’t it that such response will be specified/captured in RAN2 or Ran1 spec? |
| Nokia | According to option 1, it is beneficial to include conclusions from this investigation in RAN4 in the TR, so we support the recommended WF. |
| Qualcomm | Agree to focus on the RAN1 LS in this meeting. We don’t think the conclusions need to be captured in the TR. |
| CATT | Agree with Qualcomm and Ericsson. |
| Intel | The recommended WF is agreeable |
| Huawei | Agree with moderator that we should focus on the discussion of the reply to LS from RAN1. |

Sub-topic 1-1d: General RF scope - BS

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| **Company** | **Comments** |
| Ericsson | Option 1 seems fine till now, but should we wait RAN1 conclude their work before we conclude this? |
| Nokia | We support option 1. This is in line with not changing UE RF requirements, as commented by CATT. |
| CATT | Support option 1. |
| Huawei | We are ok with option 1. |

## Summary for 1st round

### Open issues

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|  | **Status summary** |
| **Sub-topic #1-1: Discussion scope and work plan** | **Issue 1-1a: PRS/SRS bandwidth aggregation scope**  *Candidate options:*   * Option 1: RAN4 to add the modelling of RF impairments for BW aggregation in a new Annex of the same TS/TR as used for NR CPP. A corresponding revision of the WID may be needed. * Option 2: RAN4 to carry out the work on RF performance impacts and RF impairment modelling for BW aggregation during the core part of the work item. * Option 3: No dedicated or separate RF impairment modelling discussion is needed in WI phase for the solutions based on PRS/SRS bandwidth aggregation unless it’s triggered by RAN1 LS.   *Tentative agreement:*   * *Approve Option 3*   *Recommendations for 2nd round:*   * *Confirm whether tentative agreement is acceptable*   **Issue 1-1b: Carrier phase positioning scope**  *Candidate options:*   * Option 1: RAN4 to discuss how to capture RF impairment models for NR CPP in 3GPP TS or TR. A corresponding revision of the WID may be needed. * Option 2: RAN4 to carry out the work on RF performance impacts and RF impairment modelling for NR CPP during the core part of the work item. * Option 3: Take into account the work related to RF impairments modelling for NR CPP in the work plan. * Option 4: No dedicated or separate RF impairment modelling discussion is needed in WI phase for the solutions based on carrier phase positioning unless it’s triggered by RAN1 LS.   *Tentative agreement:*   * *Approve Option 4*   *Recommendations for 2nd round:*   * *Confirm if tentative agreement is acceptable*   **Issue 1-1c: RedCap UE positioning scope**  *Candidate option:*   * Option 1: RAN4 to add RF performance characterization for frequency hopping introduced for RedCap positioning in a new Annex of the same TS/TR as used for accuracy improvements. A corresponding revision of the WID may be needed.   *Tentative agreement:*   * *Address RAN1 LS (under Sub-topic 2-3)*   *Recommendations for 2nd round:*   * *Focus on LS reply*   **Issue 1-1d: General RF scope - BS**  *Candidate options:*   * Option 1: No impact to BS RF requirements is foreseen due to the work on expanded and improved NR positioning. The scope of requirements will be limited to RRM.   *Tentative agreement:*   * *Approve Option 1*   *Recommendations for 2nd round:*   * *Confirm whether tentative agreement can be approved at this time* |

## Discussion on 2nd round

**Issue 1-1a: PRS/SRS bandwidth aggregation scope**

*Tentative agreement:*

* *Approve Option 3*
  + *Option 3: No dedicated or separate RF impairment modelling discussion is needed in WI phase for the solutions based on PRS/SRS bandwidth aggregation unless it’s triggered by RAN1 LS.*

*Recommendation for 2nd round:*

* *Confirm whether tentative agreement is acceptable*

**Issue 1-1b: Carrier phase positioning scope**

*Tentative agreement:*

* *Approve Option 4*
  + *Option 4: No dedicated or separate RF impairment modelling discussion is needed in WI phase for the solutions based on carrier phase positioning unless it’s triggered by RAN1 LS.*

*Recommendation for 2nd round:*

* *Confirm if tentative agreement is acceptable*

**Issue 1-1d: General RF scope - BS**

*Tentative agreement:*

* *Approve Option 1*
  + *Option 1: No impact to BS RF requirements is foreseen due to the work on expanded and improved NR positioning. The scope of requirements will be limited to RRM.*

*Recommendation for 2nd round:*

* *Confirm whether tentative agreement can be approved at this time*

## Companies views’ collection for 2nd round

### Open issues

Sub-topic 1-1a: PRS/SRS bandwidth aggregation scope

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| **Company** | **Comments** |
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Sub-topic 1-1b: Carrier phase positioning scope

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| **Company** | **Comments** |
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Sub-topic 1-1d: General RF scope - BS

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| **Company** | **Comments** |
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## Summary for 2nd round

### Open issues

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|  | **Status summary** |
| **Sub-topic #1-1: Discussion scope and work plan** | *TBA* |

# Topic #2: RF requirements (AI 5.23.2)

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2304440](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2304440.zip)  Discussion on UE RF impact and the reply LS on switching time for RedCap UEs | CATT | *PRS/SRS bandwidth aggregation*  **Proposal 1:** No dedicated or separate RF impairment modelling discussion is needed in WI phase for the solutions based on PRS/SRS bandwidth aggregation unless it’s triggered by RAN1 LS.  **Proposal 2:** No new UE RF requirement is needed for the solutions based on PRS / SRS bandwidth aggregation.  *Carrier phase positioning*  **Proposal 3:** No dedicated or separate RF impairment modelling discussion is needed in WI phase for the solutions based on carrier phase positioning unless it’s triggered by RAN1 LS.  **Proposal 4:** No new UE RF requirement is needed for the solutions based on carrier phase positioning.  *RedCap UE positioning*  **Observation 1:** RedCap UE positioning scenario assumption is summarized as following,   * + - The frequency hopping is limited in the same single carrier.     - The frequency hopping is limited in the TRx communication with the same BS.     - The numerology and bandwidth for each hop is the same.     - The Tx/Rx antennas used in all hops are the same.   **Proposal 5:** The following candidate values can be used for RedCap UE UL SRS Tx frequency hopping time capability,   * {100us, 140us, 200us}   **Proposal 6:** The following candidate values can be used for RedCap UE DL PRS Rx frequency hopping time capability,   * {100us, 140us, 200us} |
| [R4-2305027](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2305027.zip)  Discussion on RRM aspects in the study on Redcap positioning | ZTE Corporation | **Observation 1:** The larger the switching gap, the lower the positioning accuracy.  **Observation 2:** The values of RF retuning time (RRT) is microseconds level and shorter than the BWP switching time (RRC\_based BWP switching time is 6ms) which satisfy the frequency hopping switching time.  **Proposal 1:** Reuse the current switching time RRT for frequency hopping in redcap positioning.  **Proposal 2:** When defining the new switching time requirements for frequency hopping in redcap positioning, the current switching time RRT can be as baseline or a starting point. |
| [R4-2305035](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2305035.zip)  LS to RAN2 on switching time for DL PRS or UL SRS frequency hopping for RedCap UEs | ZTE Corporation | *LS reply content is based on R4-2305027*  **For DL-PRS:**  Follow the existed switching time values as below:   |  | | --- | | When measurement gaps are needed, the UE is not expected to detect SSB and measure RSSI of RSRQ which start earlier than the gap starting time + switching time, nor detect SSB and measure RSSI of RSRQ which end later than the gap end – switching time. Switching time is 0.5ms for frequency range FR1 and 0.25ms for frequency range FR2. |   The values of RRT is microseconds level and shorter than the BWP switching time (RRC\_based BWP switching time is 6ms) which satisfy the frequency hopping switching time.  **For UL-SRS:**  For switching time of SRS frequency hopping, we shall refer to the current specification TS38.331 SRS-SwitchingTimeNR as below:   |  | | --- | | switchingTimeUL ENUMERATED {n0us, n30us, n100us, n140us, n200us, n300us, n500us, n900us} OPTIONAL |   The value of this IE is obviously smaller than the BWP switching time, the range of switchingTimeUL is from 0us to 900us which satisfies the switching time of frequency hopping. From RAN4 perspective, when defining the concrete switching time of SRS frequency hopping, the current value can be a reference or baseline.  Based on above, that is, the shorter switching time, the higher positioning accuracy, the values for DL-PRS and UL-SRS we listed and discussed before can be a reference. |
| [R4-2305059](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2305059.zip)  Draft Reply LS on switching time for DL PRS or UL SRS frequency hopping for RedCap UEs | vivo | **Proposal 1:** Regarding the question in action part, RAN4 should provide answers for UL/DL separately.  **Proposal 2:** For the scenario one MG is used for one DL PRS hopping instance, only RF retuning time needs be considered when that MG switches between different hopping instances.  **Proposal 3:** The periodicity of that MG switching between different hopping instances could be fully determined by the duration between two different consecutive PRS instances.  **Proposal 4:** Introducing a UE capability for switching time for UL SRS frequency hopping for RedCap UEs, the candidate values are:   * {100 us, 140 us, 200 us}   *Draft LS reply content*  **DL PRS frequency hopping**  For the scenario where one MG is used for one DL PRS hopping instance, only RF retuning time needs be considered when that MG switches between different hopping instances. The periodicity of that MG switching between different hopping instances could be fully determined by the duration between two different consecutive PRS instances.  **UL SRS frequency hopping**  Introducing a UE capability for switching time for UL SRS frequency hopping for RedCap UEs, the candidate values are:   * {100 us, 140 us, 200 us} |
| [R4-2305398](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2305398.zip)  Discussion on RF requirements for bandwidth aggregated based positioning | ZTE Corporation | **Proposal 1:** the existing TAE requirement for intra-band contiguous CA in TS38.104 is not applicable if BS is declared with bandwidth aggregated based positioning functionality.  **Proposal 2:** to evaluate or derive the corresponding RF requirement for bandwidth aggregated based positioning should be based on the performance comparison between intra-band contiguous CA with some potential residual acceptable timing difference and single carrier.  **Proposal 3:** the measurement or testing feasibility of the extremely tighten requirement for bandwidth aggregated based positioning should be also taken into account.  **Observation 1:** for FR1 intra-band contiguous CA based positioning, when the relative timing difference is less than 2ns, then the positioning accuracy of intra-band contiguous CA (100+100MHz) would be better that of single carrier 100MHz.  **Observation 1:** for bandwidth aggregated based positioning in FR1 intra-band contiguous CA scenario, when the relative timing difference is less than 2ns, then the positioning accuracy of intra-band contiguous CA (100+100MHz) would be better that of single carrier 100MHz.  **Observation 2:** for bandwidth aggregated based positioning in FR2 intra-band contiguous CA scenario, when the relative timing difference is less than 2ns, then the positioning accuracy of intra-band contiguous CA would be better that of single carrier.  **Observation 3:** given the potential measurement uncertainty, it is quite challenging to test the extremely tighten timing difference requirement for bandwidth aggregated based positioning feature.  **Proposal 4:** not to define the corresponding RF requirement from BS perspective for bandwidth aggregated based positioning feature and leave it up to the vendor declaration. |
| [R4-2305461](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2305461.zip)  Reply LS to RAN 1 on switching time for DL PRS or UL SRS frequency hopping for RedCap UEs | Huawei, HiSilicon | **Proposal 1:** 140us can be taken as the largest feasible values for the switching time between intra-band inter-carrier hops.  *LS reply content*  For the DL PRS or UL SRS frequency hopping for RedCap UEs, the switching happens among 20MHz bandwidth carriers. The frequency hopping discussed in RAN1 should be intra-band scenario. Therefore, 140us can be taken as the largest feasible values. |
| [R4-2305645](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2305645.zip)  LS reply for the switching time for RedCap UE positioning | Ericsson | **Observation 1:** The total hopping time is bounded by coherence time of the channel and shorter RF tuning time benefit the positioning accuracy by increased aggregated frequency range, hence increased # of hop.  **Observation 2:** The upper limit of the RF tuning time is set either by RAN4 LS [2] with 200us in Rel-15 or 500us when capability of the switchingTimeSRS-TX-OtherTX-r17 is present.  **Observation 3:** No beam switch delay between hops considering the RAN1 assumption for FR2.  **Proposal 1:** Ask RAN1 the question if the additional switch time for first hop and switch time after last hop is relevant for RedCap frequency hopping.  *LS reply content*  The feasible values for the switching time between hops for UL SRS and DL PRS is listed in Table 1 for FR1 and Table 2 for FR2 below:  Table 1: RF retuning for UL SRS hopping and DL PRS hopping for FR1   |  |  |  |  | | --- | --- | --- | --- | |  | UL SRS | | DL PRS | | SCS | 15kHz and 30kHz | 60kHz | Any | | same UL power for different SRS transmission (e.g Intra-slot hopping) | **~ 50 us** | **~ 50 us** | **~ 50 us** | | Different UL power for different SRS transmission, (e.g inter-slot hopping) | **~ 60 us** | **~ 50 us + one blanked symbol (17.84 us) = ~67.84Us** |   Table 2: RF retuning for UL SRS hopping and DL PRS hopping for FR2   |  |  |  |  | | --- | --- | --- | --- | |  | UL SRS | | DL PRS | | SCS | 60kHz | 120kHz | Any | | same UL power for different SRS transmission (e.g Intra-slot hopping) | **~ 100 us** | **~ 100 us** | **~ 100 us** | | Different UL power for different SRS transmission, (e.g inter-slot hopping) | **~ 105 us** | **~ 100 us + one blanked symbol =~ 108.93us** |   RAN4 also thinks the additional switch time may be needed between the default BWP to the first hop and last hop to default BWP or active BWP, therefore, has below question:   * If the additional switch time between the default BWP to first hop and switch time between last hop to the default/active BWP is relevant for RedCap frequency hopping and also needs discussion in RAN |
| [R4-2305676](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2305676.zip)  Reply LS on switching time for DL PRS or UL SRS frequency hopping for RedCap UEs | Qualcomm Incorporated | **Proposal 1:** Assuming Tx/Rx frequency hopping for RedCap positioning takes place within a single frequency band, and is confined within a maximum bandwidth of 100 MHz in FR1 and 400 MHz in FR2, and the same bandwidth is maintained across hops, feasible values of switching time would be  • For FR1, one SCS15 symbol duration  • For FR2, one SCS30 symbol duration  **Proposal 2:** Define new UE capability(ies) to signal the Tx/Rx switching time supported by a RedCap UE for enhanced positioning with frequency hopping. |
| [R4-2305680](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2305680.zip)  NR positioning for RedCap UEs - switching time | Intel Corporation | **Observation 1:** Switching time impact on frequency hopping performance has been discussed in RAN1 and led to the following conclusion:   * Agreement   For the evaluation of TX/RX frequency hopping for positioning of redcap UEs, the value of the gap between two consecutive hops includes at least from 100us to 5ms.  **Observation 2:** RAN4 has been asked to assess feasible values for the switching time between hops, considering the following:   * Numerology and bandwidth for each hop can be the same * Tx/Rx antennas used in all hops can be the same * Existing BWP configuration will not be used to support SRS for positioning frequency hopping   **Observation 3:** The outcome of relevant RAN4 discussions for switching and RF retuning times is summarized below:   * MTC RF retuning time (Rel-13 eMTC)   + RAN4 conclusion on retuning time: maximum retuning time between narrowband regions is 2 symbols including CP length assuming normal CP * UE RF bandwidth adaptation   + FR1 intra-band with center frequency change: transition time is 50 – 200µs   + FR1 inter-band: transition time up to 900µs * NR SRS carrier switching time   + Intra-band CA: 0µs, 30µs, 100µs, 140µs and 200µs   + Inter-band CA: 0µs, 30µs, 100µs, 200µs, 300µs, 500µs and 900µs * NR UL/SUL switching (UL sharing in EN-DC)   + When SUL is not the same band as LTE or there is more than one LTE, NR or SUL band, 140µs switching time applies between NR UL and NR SUL * Switching time candidate values when transmitting SRS outside initial UL BWP or with different SCS than initial BWP   + {100µs, 140µs, 200µs, 300µs, 500µs}   **Observation 4:** Given the lighter load compared to BWP switching, the SRS carrier switching time values for intra-band CA and the UE RF bandwidth adaptation retuning time range of 50-200µs, it is reasonable to have the switching time for FR1 not exceed the MTC retuning time of 2 symbols of 15kHz SCS (140µs).  **Proposal 1:** Further discuss defining the switching time for SRS frequency hopping based on a UE capability with values up to 140µs for both FR1 and FR2. |
| [R4-2305693](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2305693.zip)  UE RF requirements for Rel-18 NR positioning | Nokia, Nokia Shanghai Bell | *Frequency hopping for RedCap UEs*  **Observation 1:** In case the RedCap device has two receive chains with independent PLLs, they can be used alternately for the frequency hops i.e., when one chain is actively receiving, the other chain can be preconfigured corresponding to the RF configuration of the next frequency hop. This condition leads to the smallest possible switching time at the cost of diversity gain.  **Observation 2:** For RedCap UEs with only single receive chain, as there is no standby receiver available, they must be reconfigured for each frequency hop. The minimum RF configuration change corresponds to the case where only the centre frequency of the carrier is changed without changing the bandwidth and numerology. In this case, only the PLL settling time should govern the switching time.  **Observation 3:** In case of SRS transmission, the hop time can be in the order of couple of micro-seconds.  **Observation 4:** In uplink case, one of the use cases of transmit power time mask is to define the transient period(s) allowed between continuous ON-power transmissions with RB hopping. The shortest transient time based on UE capabilities can be 2µs, with default being 10µs [2] for FR1. This hop is within 20 MHz only in case of FR1.  **Observation 5:** Minimum UE receiver reconfiguration time is implementation specific and does require an input from different UE vendors.  **Proposal 1:** There can be a difference in switching time between 1Rx and 2 Rx RedCap UEs.  **Proposal 2:** We encourage UE vendors to share their views on what can be the possible hop time for PRS reception.  **Proposal 3:** We encourage UE vendors to share their views on what can be the possible hop time for SRS transmission.  *NR carrier phase positioning*  **Proposal 4:** RAN4 shall define the assumptions required for the evaluation framework for NR carrier phase positioning.  **Proposal 5:** We encourage companies to review TR 38.859 and identify the missing aspects required to assess the impairments for NR carrier phase positioning. |

## Open issues summary

### Sub-topic 2-1: PRS/SRS bandwidth aggregation

*Way Forward for PRS/SRS bandwidth aggregation (R4-2303570):*

* *Consider conclusions in TR 38.859 and further discuss RF impairment modelling, if needed*
* *Identify and discuss potential RF requirement impact*

**Issue 2-1: RF requirement for bandwidth aggregated-based positioning**

* Proposals
  + Option 1: No new UE RF requirement is needed for the solutions based on PRS / SRS bandwidth aggregation. (CATT, R4-2304440)
  + Option 2: the existing TAE requirement for intra-band contiguous CA in TS38.104 is not applicable if BS is declared with bandwidth aggregated based positioning functionality. (ZTE, R4-2305398)
  + Option 3: to evaluate or derive the corresponding RF requirement for bandwidth aggregated based positioning should be based on the performance comparison between intra-band contiguous CA with some potential residual acceptable timing difference and single carrier. (ZTE, R4-2305398)
  + Option 4: the measurement or testing feasibility of the extremely tighten requirement for bandwidth aggregated based positioning should be also taken into account. (ZTE, R4-2305398)
  + Option 5: not to define the corresponding RF requirement from BS perspective for bandwidth aggregated based positioning feature and leave it up to the vendor declaration. (ZTE, R4-2305398)
* Recommended WF
  + Note that scope is discussed under [**Sub-topic 1-1**](#_Sub-topic_1-1:_Discussion) (Issue 1-1a)
  + Companies are encouraged to share their views on the above options
    - Comment on whether a new UE RF requirement will be needed
    - Consider if requirement can be left up to vendor declaration

### Sub-topic 2-2: Carrier phase positioning

*Way Forward for carrier phase positioning (R4-2303570):*

* *Consider conclusions of RAN1’s study (TR 38.859) and further discuss RF impairment modelling, if needed*
* *Identify and discuss RF requirement impact (if any)*

**Issue 2-2: RF requirement for carrier phase positioning**

* Proposals
  + Option 1: No new UE RF requirement is needed for the solutions based on carrier phase positioning. (CATT, R4-2304440)
  + Option 2: RAN4 shall define the assumptions required for the evaluation framework for NR carrier phase positioning. (Nokia, R4-2305693)
  + Option 3: We encourage companies to review TR 38.859 and identify the missing aspects required to assess the impairments for NR carrier phase positioning. (Nokia, R4-2305693)
* Recommended WF
  + Note that scope is discussed under [**Sub-topic 1-1**](#_Sub-topic_1-1:_Discussion) (Issue 1-1b)
  + Companies are invited to comment on the above options
    - Consider whether a new UE RF requirement will be needed

### Sub-topic 2-3: RedCap UE positioning

*Way forward conclusion in RAN4 #106 was to further discuss the RF impact of frequency hopping based on details provided by RAN1 (R4-2303570). RAN4 received an LS from RAN1 on the switching time for DL PRS or UL SRS frequency hopping for RedCap UEs with the following request (R1-2302127):*

**To RAN4**

**ACTION:**

RAN1 kindly asks RAN4 for feedback on the feasible values for the switching time between hops, at least when numerology and bandwidth for each hop can be the same, and the Tx/Rx antennas used in all hops can be the same.

*Additionally, the content below was included in the LS:*

**Conclusion**

For positioning enhancements for RedCap UEs, only Rx frequency hopping of the DL PRS is supported.

**Agreement**

For RedCap UEs, support at least measurements on DL PRS with Rx frequency hopping using a measurement gap

* FFS: details on RedCap UE processing capabilities for DL PRS with Rx frequency hopping and MG
* FFS: the use of a single or multiple instances of a MGs
* FFS: the use of PPW

**Conclusion**

The scope for RedCap positioning includes FR1 and FR2.

**Agreement**

For Positioning enhancements for redcap UEs for UL SRS Tx and DL PRS Rx frequency hopping, from the RAN1 perspective, short switching time to allow RF retuning between adjacent hops may be beneficial in terms of accuracy and latency performance.

* Send an LS to RAN4 requesting feedback on the feasible values for the switching time between hops, at least when numerology and bandwidth for each hops can be the same, and the Tx/Rx antennas used in all hops can be the same.

**Agreement**

For positioning for RedCap UEs with DL PRS Rx Hopping, the UE hops within a DL PRS resource

* FFS: whether there is specification update needed for RAN1
* FFS: remaining details

**Agreement**

For RedCap UEs, support SRS for positioning frequency hopping by

* Using a configuration separate from the existing BWP configuration
  + FFS: hopping is configured within a SRS resource or across SRS resources

**Issue 2-3a: General considerations for switching time**

* Proposals
  + Option 1: Reuse the current switching time RF retuning time (RRT) for frequency hopping in redcap positioning. (ZTE, R4-2305027)
    - Existing RRT is shorter than BWP switching time (TS 38.133)

When measurement gaps are needed, the UE is not expected to detect SSB and measure RSSI of RSRQ which start earlier than the gap starting time + switching time, nor detect SSB and measure RSSI of RSRQ which end later than the gap end – switching time. Switching time is 0.5ms for frequency range FR1 and 0.25ms for frequency range FR2.

* + Option 2: When defining the new switching time requirements for frequency hopping in redcap positioning, the current switching time RRT can be as baseline or a starting point. (ZTE, R4-2305027)
  + Option 3: Regarding the question in action part, RAN4 should provide answers for UL/DL separately. (vivo, R4-2305059)
  + Option 4: Ask RAN1 the question if the additional switch time for first hop and switch time after last hop is relevant for RedCap frequency hopping. (Ericsson, R4-2305645)
  + Option 5: There can be a difference in switching time between 1Rx and 2 Rx RedCap UEs. (Nokia, R4-2305693)
* Recommended WF
  + Companies should provide their views on the listed options, and which are agreeable

**Issue 2-3b: UE capability for switching time**

*As captured in the options below, several companies proposed introducing a new capability for the switching time supported by RedCap UEs with frequency hopping*

* Proposals
  + Option 1: The following candidate values can be used for RedCap UE UL SRS Tx frequency hopping time capability, (CATT, R4-2304440)
    - {100us, 140us, 200us}
  + Option 2: Introducing a UE capability for switching time for UL SRS frequency hopping for RedCap UEs, the candidate values are: (vivo, R4-2305059)
    - {100 us, 140 us, 200 us}
  + Option 3: Define new UE capability(ies) to signal the Tx/Rx switching time supported by a RedCap UE for enhanced positioning with frequency hopping. (Qualcomm, R4-2305676)
  + Option 4: Further discuss defining the switching time for SRS frequency hopping based on a UE capability with values up to 140µs for both FR1 and FR2. (Intel, R4-2305680)
* Recommended WF
  + Companies are encouraged to confirm whether it is agreeable to introduce a new capability for the switching time (candidate values are TBD and will be addressed in upcoming issues)

**Issue 2-3c: UL SRS Tx frequency hopping**

* Proposals
  + Option 1: The following candidate values can be used for RedCap UE UL SRS Tx frequency hopping time capability, (CATT, R4-2304440)
    - {100us, 140us, 200us}
  + Option 2: Introducing a UE capability for switching time for UL SRS frequency hopping for RedCap UEs, the candidate values are: (vivo, R4-2305059)
    - {100 us, 140 us, 200 us}
  + Option 3: 140us can be taken as the largest feasible values for the switching time between intra-band inter-carrier hops. (Huawei, R4-2305461)
  + Option 4: Ericsson, R4-2305645
    - For FR1, 50us for intra-slot hopping and 60us for SCS 15kHz and 30kHz for inter-slot hopping, 67 us for SCS 60kHz for inter-slot hopping
    - For FR2, 109us
  + Option 5: Assuming Tx/Rx frequency hopping for RedCap positioning takes place within a single frequency band, and is confined within a maximum bandwidth of 100 MHz in FR1 and 400 MHz in FR2, and the same bandwidth is maintained across hops, feasible values of switching time would be (Qualcomm, R4-2305676)
    - For FR1, one SCS15 symbol duration
    - For FR2, one SCS30 symbol duration
  + Option 6: Further discuss defining the switching time for SRS frequency hopping based on a UE capability with values up to 140µs for both FR1 and FR2. (Intel, R4-2305680)
* Recommended WF
  + Companies are invited to share their views on candidate values for UL SRS Tx frequency hopping
    - Comment on range and largest feasible switching time values for both FR1 and FR2

**Issue 2-3d: DL PRS Rx frequency hopping**

* Proposals
  + Option 1: The following candidate values can be used for RedCap UE DL PRS Rx frequency hopping time capability, (CATT, R4-2304440)
    - {100us, 140us, 200us}
  + Option 2: For the scenario one MG is used for one DL PRS hopping instance, only RF retuning time needs be considered when that MG switches between different hopping instances. (vivo, R4-2305059)
  + Option 3: The periodicity of that MG switching between different hopping instances could be fully determined by the duration between two different consecutive PRS instances. (vivo, R4-2305059)
  + Option 3: 140us can be taken as the largest feasible values for the switching time between intra-band inter-carrier hops. (Huawei, R4-2305461)
  + Option 4: 50us for FR1 and 100us for FR2. (Ericsson, R4-2305645)
  + Option 5: Assuming Tx/Rx frequency hopping for RedCap positioning takes place within a single frequency band, and is confined within a maximum bandwidth of 100 MHz in FR1 and 400 MHz in FR2, and the same bandwidth is maintained across hops, feasible values of switching time would be (Qualcomm, R4-2305676)
    - For FR1, one SCS15 symbol duration
    - For FR2, one SCS30 symbol duration
  + Option 6: Further discuss defining the switching time based on a UE capability with values up to 140µs for both FR1 and FR2. (Intel, R4-2305680)
* Recommended WF
  + Companies to discuss candidate values for DL PRS Rx frequency hopping
    - Comment on range and largest feasible switching time values for both FR1 and FR2

**Issue 2-3e: LS reply**

* Proposals
  + Option 1: CATT, R4-2304440
    - The following candidate values can be used for RedCap UE UL SRS Tx frequency hopping time capability,
      * {100us, 140us, 200us}
    - The following candidate values can be used for RedCap UE DL PRS Rx frequency hopping time capability,
      * {100us, 140us, 200us}
    - Please note that the above capability replies are based on the following assumptions according to RAN4 understanding of RAN1 RedCap UE positioning study in current release,
      * The frequency hopping is limited in the same single carrier.
      * The frequency hopping is limited in the TRx communication with the same BS.
      * The numerology and bandwidth for each hop is the same.
      * The Tx/Rx antennas used in all hops are the same.
  + Option 2: ZTE, R4-2305035
    - **For DL-PRS:**

Follow the existed switching time values as below:

When measurement gaps are needed, the UE is not expected to detect SSB and measure RSSI of RSRQ which start earlier than the gap starting time + switching time, nor detect SSB and measure RSSI of RSRQ which end later than the gap end – switching time. Switching time is 0.5ms for frequency range FR1 and 0.25ms for frequency range FR2.

The values of RRT is microseconds level and shorter than the BWP switching time (RRC\_based BWP switching time is 6ms) which satisfy the frequency hopping switching time.

* + - **For UL-SRS:**

For switching time of SRS frequency hopping, we shall refer to the current specification TS38.331 SRS-SwitchingTimeNR as below:

|  |
| --- |
| switchingTimeUL ENUMERATED {n0us, n30us, n100us,n140us, n200us, n300us, n500us, n900us} OPTIONAL |

The value of this IE is obviously smaller than the BWP switching time, the range of switchingTimeUL is from 0us to 900us which satisfies the switching time of frequency hopping. From RAN4 perspective, when defining the concrete switching time of SRS frequency hopping, the current value can be a reference or baseline.

* + Option 3: vivo, R4-2305059
    - **DL PRS frequency hopping**

For the scenario where one MG is used for one DL PRS hopping instance, only RF retuning time needs be considered when that MG switches between different hopping instances. The periodicity of that MG switching between different hopping instances could be fully determined by the duration between two different consecutive PRS instances.

* + - **UL SRS frequency hopping**

Introducing a UE capability for switching time for UL SRS frequency hopping for RedCap UEs, the candidate values are:

• {100 us, 140 us, 200 us}

* + Option 4: Huawei, R4-2305461
    - For the DL PRS or UL SRS frequency hopping for RedCap UEs, the switching happens among 20MHz bandwidth carriers. The frequency hopping discussed in RAN1 should be intra-band scenario. Therefore, 140us can be taken as the largest feasible values.
  + Option 5: Ericsson, R4-2305645
    - The feasible values for the switching time between hops for UL SRS and DL PRS is listed in Table 1 for FR1 and Table 2 for FR2 below:

Table 1: RF retuning for UL SRS hopping and DL PRS hopping for FR1

|  |  |  |  |
| --- | --- | --- | --- |
|  | UL SRS | | DL PRS |
| SCS | 15kHz and 30kHz | 60kHz | Any |
| same UL power for different SRS transmission (e.g Intra-slot hopping) | **~ 50 us** | **~ 50 us** | **~ 50 us** |
| Different UL power for different SRS transmission, (e.g inter-slot hopping) | **~ 60 us** | **~ 50 us + one blanked symbol (17.84 us) = ~67.84Us** |

Table 2: RF retuning for UL SRS hopping and DL PRS hopping for FR2

|  |  |  |  |
| --- | --- | --- | --- |
|  | UL SRS | | DL PRS |
| SCS | 60kHz | 120kHz | Any |
| same UL power for different SRS transmission (e.g Intra-slot hopping) | **~ 100 us** | **~ 100 us** | **~ 100 us** |
| Different UL power for different SRS transmission, (e.g inter-slot hopping) | **~ 105 us** | **~ 100 us + one blanked symbol =~ 108.93us** |

* + - RAN4 also thinks the additional switch time may be needed between the default BWP to the first hop and last hop to default BWP or active BWP, therefore, has below question:
      * If the additional switch time between the default BWP to first hop and switch time between last hop to the default/active BWP is relevant for RedCap frequency hopping and also needs discussion in RAN
* Recommended WF
  + Focus on Issues 2-3a through 2-3d first. Once we have made progress on these, then we can decide if a reply can be sent during this meeting and what reply option to use as baseline.

## Companies views’ collection for 1st round

### Open issues

Sub-topic 2-1: RF requirement for bandwidth aggregated-based positioning

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | We agree with no RF for BS in option 5, but not sure about the vendor declaration part, as it is not testable so declaration does not help either.  For UE RF requirement aspect, the study phase conclude with the single RF chain. Similar with BS discussion, it will be difficult to test and set the group delay requirement and therefore, we support option 1. |
| ZTE | We are fine not to define the requirement for it from both BS and UE side due to its test issues, however without any declaration from vendors, it might be also risky to support this feature, right? |
| Nokia | We don’t see the necessity for new RF requirements for UE or BS, thus we support options 1 and 5. But the RF impairments need to be taken into account in particular for modelling the impact to TOA measurement accuracy. The improved measurement accuracy in RRM is expected to be testable. |
| Qualcomm | Regarding option 2, in the study phase it was agreed not to consider TAE for PRS BW aggregation scenarios declared feasible by RAN4.  Regarding option 1 and option 5, our understanding is that the impact of RF impairments, e.g. residual group delay error, will be taken into account when specifying performance requirements for measurements with PRS/SRS BW aggregation. That work will be carried out in RRM. TBD if there is any support/impact to RF. |
| CATT | Option 1. For the declaration approach of option 5, not sure how it be implemented in spec if there’s no requirement. |
| Intel | RF impairments will be considered in RRM discussions. As captured in the approved work plan, these may be further discussed if needed.  We are ok with Option 1. Further discussion is needed for Option 5. As CATT noted, it is not clear how a declaration would work in this situation. |
| Huawei | We are ok not to define the requirement from BS and UE side for now. |

Sub-topic 2-2: RF requirement for carrier phase positioning

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | We support option 1. |
| Nokia | We don’t see the necessity for new RF requirements for UE or BS. But the RF impairments need to be taken into account in particular for modelling the impact to CP measurement accuracy. The improved measurement accuracy in RRM is expected to be testable. Thus, we support options 1, 2 and 3. |
| Qualcomm | We support option 1 but we’re also OK to leave it as FFS for now. |
| CATT | Option 1. The RF impact can be discussed in RRM requirement discussion if it’s needed. |
| Huawei | Option 1 |

Sub-topic 2-3a: General considerations for switching time

Sub-topic 2-3b: UE capability for switching time

Sub-topic 2-3c: UL SRS Tx frequency hopping

Sub-topic 2-3d: DL PRS Rx frequency hopping

Sub-topic 2-3e: LS reply

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Ericsson | Sub-topic 2-3a: for option 1, maybe a clarification on the unit of time, is this a mili second or micro second? If it is millisecond, it is too big. But if ZTE understanding is shorter is better, we share similar view.  sub-topic 2-3b: our view is that RAN4 should discuss the value first, if there is only one value agreed, then there is no need on capability. Then the question relate to feature support by UE, if it optional feature, then no need on capability on switch time, so saving the signalling aspect.  Sub-topic 2-3c: we support both option 4 and option 5. We agree also option 6, but without UE capability part as this is different discussion.  For option 1, 2 and 3, the switch time can be shorter as the switching time is about between hop swiching, the legacy value covers also time between Tx in initial BWP and SRS Tx. This time could be suitable to the switching time between initial BWP to first hop and last hop to the initial BWP.  Sub-topic 2-3d: we support both option 4 and option 5. We agree also option 6, but without UE capability part as this is different discussion.  for option 2, we think this should be the case where LS question is asked about. For option 3, maybe proponent can clarify if this is valid case discussing in RAN1?  Sub-topic 2-3e: agree with WF, need discuss the value first. |
| Nokia | Sub-topic 2-3a: General considerations for switching time  Options 3 and 5 are applicable for general considerations. Option 5 is applicable in case RAN4 defines different switching times for DL and UL. The LS should consider splitting the reply accordingly.  Sub-topic 2-3b: UE capability for switching time  We are ok to consider the range for switching times of SRS frequency hopping, as outlined in R4-2305035, as a starting point both for UL and DL. Our preference is to agree on a single value for FR1 and FR2, respectively, such as proposed in the draft LS ([R4-2305461](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_106Bis-e/Docs/R4-2305461.zip)). This is in order to keep the number of FH patterns within a measurement gap / measurement window low in a given FR. If consensus on a single value in a given FR cannot be reached, then RAN4 needs to define a minimum set of switching times per FR, which may or not be different for DL or UL, thereby requiring to signal the UE capability. In particular for RedCap, consideration must be given both for 1 Rx UE and for 2 Rx UE. It is desirable not to distinguish between switching times for 1 Rx UE and 2 Rx UE to enable the use of the same FH pattern within a measurement gap / measurement window in a given FR.  Sub-topic 2-3c: UL SRS Tx frequency hopping  The switching time for SRS frequency hopping can serve as a starting point. RAN4 should agree a minimum of switching times per FR for UL Tx FH. It can be checked whether a medium value of 140 us is agreeable.  Sub-topic 2-3d: DL PRS Rx frequency hopping  The switching time for SRS frequency hopping can serve as a starting point. RAN4 should agree a minimum of switching times per FR for DL Rx FH. It can be checked whether a medium value of 140 us is agreeable.  Sub-topic 2-3e: LS reply  We support the recommended WF. |
| Qualcomm | **Issue 2-3a: General considerations for switching time**  Regarding option 1 and 2, the current RRT for measurement gaps may be taken as an upper bound, at least for DL. However, it would be a conservative upper bound given the additional constraints/assumptions specified by RAN1 in the LS.  Regarding option 3, we suggest to discuss feasible values and see if a distinction needs to be made between UL/DL.  Regarding option 4, the question from RAN1 was specifically about switching time between hops. RAN4 can provide an answer to that question and may ask the question proposed above. For DL, the agreement from RAN1 is to support Rx hopping measurements with measurement gaps. In that case, there is retuning time provided at the beginning and at the end of each gap.  **Issue 2-3b: UE capability for switching time**  Support option 3 but OK to discuss the feasible values first. Based on the range of values being proposed it is likely that a capability will be needed to accommodate different implementations.  **Issue 2-3c: UL SRS Tx frequency hopping**  Candidate switching time values  FR1: {70 us, 140 us}  FR2: {35 us, 70 us}  **Issue 2-3d: DL PRS Rx frequency hopping**  Candidate switching time values  FR1: {70 us, 140 us}  FR2: {35 us, 70 us}  **Issue 2-3e: LS reply**  Support the recommended WF. |
| vivo | **Sub-topic 2-3a:**  Support option 3. Since DL and UL use different approaches, RAN4 should provide answers for UL/DL separately.  **Sub-topic 2-3b:**  We agree to introduce a new capability for switching time for UL SRS frequency hopping for RedCap UEs. But it is OK to discuss the feasible value first.  **Sub-topic 2-3c:**  Support option 1 and option 2. For UL SRS frequency hopping, there is also no transition time required from the baseband perspective. For RF transition time, the values from the SRS carrier switching capability can be referred to   * {0 us, 30 us, 100 us, 140 us, 200 us, 300 us, 500 us, 900 us}   However, for 0 us and 30 us, the UE should at least have two RF chains. The switching time can be 0 us because UE can prepare the RF chain in advance separately. For 30 us, the RF switching time only consists of the antenna switching time between two bands, e.g. 10~30us [R4-167659]. Thus, we do not recommend the value 0 and 30 to be re-used for RedCap UE. Also, 300 us, 500 us, 900 us are for inter-band CA scenario [R4-1811534]. Thus, the following candidate values can be re-used.   * {100 us, 140 us, 200 us}   **Sub-topic 2-3d:**  Regarding topic 2-3d, we focus on the following agreement ‘FFS: the use of a single or multiple instances of a MGs’ and provide analysis when this methodology is used. as illustrated in Fig. 1.    Fig. 1. One MG instance for one hop  For option 2, we propose to only consider the RF retuning time when that MG switches between different hopping instances in this scenario. For option 3, the RF retuning has already been absorbed into the MGL part, theoretically the minimum switch time when a MG switches between two different hopping instances could be 0 then the periodicity of that MG switching between different hopping instances could be fully determined by the duration between different consecutive PRS instances.  However, if the focus is the range and largest feasible switching time values for both FR1 and FR2 as suggested WF, we are ok with option 1.  **Sub-topic 2-3e:**  Agree with the recommended WF. |
| CATT | **Issue 2-3a: General considerations for switching time**  For option 1 and option 2, we agree that current capability can be assumed but it’s better the exact values are sent to RAN1.  For option 3, we don’t understand the difference between DL and UL, if the RF retuning time is the technical issues.  For option 4, our understanding is that RAN4 replying RF capability, then RAN1 can decide how to handle them.  For option 5, we would like to know the technical justification.  **Issue 2-3b: UE capability for switching time**  **Issue 2-3c: UL SRS Tx frequency hopping**  **Issue 2-3d: DL PRS Rx frequency hopping**  Our proposal is based on the history discussion but we’re happy to agree smaller values.  The same comment as above.  **Issue 2-3e: LS reply**  Support the recommended WF. |
| Intel | Sub-topic 2-3a: General considerations for switching time  Regarding using the current RRT as baseline, we think it is ok to consider these in the discussion. However, our view is that it can be less.  Sub-topic 2-3b: UE capability for switching time  We support introducing this UE capability if needed depending on the outcome of the feasible values discussion.  Sub-topic 2-3c: UL SRS Tx frequency hopping  We are open to further discussion, but think value should not exceed 140us  Sub-topic 2-3d: DL PRS Rx frequency hopping  We are open to further discussion, but think the value should not exceed 140us  Sub-topic 2-3e: LS reply  We support the recommended WF to address the values first |
| Huawei | **Sub-topic 2-3b:**  Introducing a capability is ok to us.  **Sub-topic 2-3c/d:**  Support Option 3.  **Sub-topic 2-3e:**  Support Option 4. |

## Summary for 1st round

### Open issues

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic #2-1: PRS/SRS bandwidth aggregation** | **Issue 2-1: RF requirement for bandwidth aggregated-based positioning**  *Candidate options:*   * Option 1: No new UE RF requirement is needed for the solutions based on PRS / SRS bandwidth aggregation. * Option 2: the existing TAE requirement for intra-band contiguous CA in TS38.104 is not applicable if BS is declared with bandwidth aggregated based positioning functionality. * Option 3: to evaluate or derive the corresponding RF requirement for bandwidth aggregated based positioning should be based on the performance comparison between intra-band contiguous CA with some potential residual acceptable timing difference and single carrier. * Option 4: the measurement or testing feasibility of the extremely tighten requirement for bandwidth aggregated based positioning should be also taken into account. * Option 5: not to define the corresponding RF requirement from BS perspective for bandwidth aggregated based positioning feature and leave it up to the vendor declaration.   *Majority view is that there is no need for new RF requirements. However, Option 5 needs further discussion and clarification.*  *Tentative agreement:*   * *Approve Option 1*   *Recommendations for 2nd round:*   * *Confirm if the tentative agreement is acceptable* * *Discuss whether we can also agree to not define RF requirements for BS* |
| **Sub-topic #2-2: Carrier phase positioning** | **Issue 2-2: RF requirement for carrier phase positioning**  *Candidate options:*   * Option 1: No new UE RF requirement is needed for the solutions based on carrier phase positioning. * Option 2: RAN4 shall define the assumptions required for the evaluation framework for NR carrier phase positioning. * Option 3: We encourage companies to review TR 38.859 and identify the missing aspects required to assess the impairments for NR carrier phase positioning.   *Tentative agreement:*   * *Approve Option 1*   *Recommendations for 2nd round:*   * *Confirm tentative agreement* |
| **Sub-topic #2-3: RedCap UE positioning** | **Issue 2-3a: General considerations for switching time**  *Candidate options:*   * Option 1: Reuse the current switching time RF retuning time (RRT) for frequency hopping in redcap positioning. * Option 2: When defining the new switching time requirements for frequency hopping in redcap positioning, the current switching time RRT can be as baseline or a starting point. * Option 3: Regarding the question in action part, RAN4 should provide answers for UL/DL separately. * Option 4: Ask RAN1 the question if the additional switch time for first hop and switch time after last hop is relevant for RedCap frequency hopping. * Option 5: There can be a difference in switching time between 1Rx and 2 Rx RedCap UEs.   *Companies are generally ok to consider Option 1 and Option 2 in discussions (though values are likely an upper bound). Option 3 will be part of the feasible value discussions. While Option 4 can be further discussed, its answer should have no impact on the switching time between hops.*  *Recommendations for 2nd round:*   * *Consider the above discussion summary and focus on the feasible value discussions in Issue 2-3c and 2-3d*   **Issue 2-3b: UE capability for switching time**  *Candidate options:*   * Option 1: The following candidate values can be used for RedCap UE UL SRS Tx frequency hopping time capability,   + - {100us, 140us, 200us}   + Option 2: Introducing a UE capability for switching time for UL SRS frequency hopping for RedCap UEs, the candidate values are:     - {100 us, 140 us, 200 us}   + Option 3: Define new UE capability(ies) to signal the Tx/Rx switching time supported by a RedCap UE for enhanced positioning with frequency hopping.   + Option 4: Further discuss defining the switching time for SRS frequency hopping based on a UE capability with values up to 140µs for both FR1 and FR2.   *Recommendations for 2nd round:*   * *Focus on Issue 2-3c and 2-3d first, then address capability based on the outcome of those discussions*   **Issue 2-3c: UL SRS Tx frequency hopping**  *Candidate option:*   * Option 1: The following candidate values can be used for RedCap UE UL SRS Tx frequency hopping time capability,   + - {100us, 140us, 200us}   + Option 2: Introducing a UE capability for switching time for UL SRS frequency hopping for RedCap UEs, the candidate values are:     - {100 us, 140 us, 200 us}   + Option 3: 140us can be taken as the largest feasible values for the switching time between intra-band inter-carrier hops.   + Option 4:     - For FR1, 50us for intra-slot hopping and 60us for SCS 15kHz and 30kHz for inter-slot hopping, 67 us for SCS 60kHz for inter-slot hopping     - For FR2, 109us   + Option 5: Assuming Tx/Rx frequency hopping for RedCap positioning takes place within a single frequency band, and is confined within a maximum bandwidth of 100 MHz in FR1 and 400 MHz in FR2, and the same bandwidth is maintained across hops, feasible values of switching time would be     - For FR1, one SCS15 symbol duration     - For FR2, one SCS30 symbol duration   + Option 6: Further discuss defining the switching time for SRS frequency hopping based on a UE capability with values up to 140µs for both FR1 and FR2.   *Recommendations for 2nd round:*   * *Further discuss during GTW session and consider the following:*   + *Option 1: {100us, 140us, 200us} for FR1 and FR2*   + *Option 2:*     - *FR1: {70us, 140us}*     - *FR2: {35us, 70us}*   + *Option 3: 140us as largest feasible value for FR1 and FR2*   **Issue 2-3d: DL PRS Rx frequency hopping**  *Candidate options:*   * Option 1: The following candidate values can be used for RedCap UE DL PRS Rx frequency hopping time capability,   + {100us, 140us, 200us} * Option 2: For the scenario one MG is used for one DL PRS hopping instance, only RF retuning time needs be considered when that MG switches between different hopping instances. * Option 3: The periodicity of that MG switching between different hopping instances could be fully determined by the duration between two different consecutive PRS instances. * Option 3: 140us can be taken as the largest feasible values for the switching time between intra-band inter-carrier hops. * Option 4: 50us for FR1 and 100us for FR2 * Option 5: Assuming Tx/Rx frequency hopping for RedCap positioning takes place within a single frequency band, and is confined within a maximum bandwidth of 100 MHz in FR1 and 400 MHz in FR2, and the same bandwidth is maintained across hops, feasible values of switching time would be   + For FR1, one SCS15 symbol duration   + For FR2, one SCS30 symbol duration * Option 6: Further discuss defining the switching time based on a UE capability with values up to 140µs for both FR1 and FR2.   *Recommendations for 2nd round:*   * *Further discuss during GTW session and consider the following:*   + *Option 1: {100us, 140us, 200us} for FR1 and FR2*   + *Option 2:*     - *FR1: {70us, 140us}*     - *FR2: {35us, 70us}*   + *Option 3: 140us as largest feasible value for FR1 and FR2*   **Issue 2-3e: LS reply**  *Candidate options:*   * Option 1: CATT, R4-2304440 * Option 2: ZTE, R4-2305035 * Option 3: vivo, R4-2305059 * Option 4: Huawei, R4-2305461 * Option 5: Ericsson, R4-2305645   *Recommendation for 2nd round:*   * *Focus discussions on Issue 2-3c and 2-3d during GTW session and second round* * *Based on the progress made, decide if a reply can be sent during this meeting and what option to use as baseline* |

## Discussion on 2nd round

**Issue 2-1: RF requirement for bandwidth aggregated-based positioning**

*Tentative agreement:*

* *Approve Option 1*
  + *Option 1: No new UE RF requirement is needed for the solutions based on PRS / SRS bandwidth aggregation.*

*Recommendation for 2nd round:*

* *Confirm if the tentative agreement is acceptable and whether we can also agree to not define RF requirements for BS*

**Issue 2-2: RF requirement for carrier phase positioning**

*Tentative agreement:*

* *Approve Option 1*
  + *Option 1: No new UE RF requirement is needed for the solutions based on carrier phase positioning.*

*Recommendation for 2nd round:*

* *Confirm tentative agreement*

**Issue 2-3c: UL SRS Tx frequency hopping**

*Recommendation for 2nd round:*

* *Consider the following:*
  + *Option 1: {100us, 140us, 200us} for FR1 and FR2*
  + *Option 2:*
    - *FR1: {70us, 140us}*
    - *FR2: {35us, 70us}*
  + *Option 3: 140us as largest feasible value for FR1 and FR2*

**Issue 2-3d: DL PRS Rx frequency hopping**

*Recommendation for 2nd round:*

* *Further discuss considering the following:*
  + *Option 1: {100us, 140us, 200us} for FR1 and FR2*
  + *Option 2:*
    - *FR1: {70us, 140us}*
    - *FR2: {35us, 70us}*
  + *Option 3: 140us as largest feasible value for FR1 and FR2*

**Issue 2-3e: LS reply**

*Recommendation for 2nd round:*

* *Focus discussions on Issue 2-3c and 2-3d during GTW session and second round*
* *Based on the progress made, decide if a reply can be sent during this meeting and what option to use as baseline*
  + *Discussions can then focus on drafting the LS reply*

## Companies views’ collection for 2nd round

### Open issues

Issue 2-1: RF requirement for bandwidth aggregated-based positioning

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| **Company** | **Comments** |
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Issue 2-2: RF requirement for carrier phase positioning

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| **Company** | **Comments** |
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Issue 2-3c: UL SRS Tx frequency hopping

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| **Company** | **Comments** |
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Issue 2-3d: DL PRS Rx frequency hopping

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| **Company** | **Comments** |
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Issue 2-3e: LS reply

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| **Company** | **Comments** |
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## Summary for 2nd round

### Open issues

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| --- | --- |
|  | **Status summary** |
| **Sub-topic #2-1** | *TBA* |

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |  |
| --- | --- | --- | --- |
| **New Tdoc number** | **Title** | **Source** | **Comments** |
|  | WF on UE RF aspects for Rel-18 NR positioning | Intel Corporation |  |
|  |  |  |  |

**Existing tdocs**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tdoc number** | **Revised to** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-2304440 |  | Discussion on UE RF impact and the reply LS on switching time for RedCap UEs | CATT | Return to |  |
| R4-2305027 |  | Discussion on RRM aspects in the study on Redcap positioning | ZTE Corporation | Noted |  |
| R4-2305035 |  | LS to RAN2 on switching time for DL PRS or UL SRS frequency hopping for RedCap UEs | ZTE Corporation | Return to |  |
| R4-2305059 |  | Draft Reply LS on switching time for DL PRS or UL SRS frequency hopping for RedCap UEs | vivo | Return to |  |
| R4-2305398 |  | Discussion on RF requirements for bandwidth aggregated based positioning | ZTE Corporation | Noted |  |
| R4-2305461 |  | Reply LS to RAN 1 on switching time for DL PRS or UL SRS frequency hopping for RedCap UEs | Huawei, HiSilicon | Return to |  |
| R4-2305645 |  | LS reply for the switching time for RedCap UE positioning | Ericsson | Return to |  |
| R4-2305676 |  | Reply LS on switching time for DL PRS or UL SRS frequency hopping for RedCap UEs | Qualcomm Incorporated | Noted |  |
| R4-2305680 |  | NR positioning for RedCap UEs - switching time | Intel Corporation | Noted |  |
| R4-2305687 |  | General aspects for Rel-18 NR positioning | Nokia, Nokia Shanghai Bell | Noted |  |
| R4-2305693 |  | UE RF requirements for Rel-18 NR positioning | Nokia, Nokia Shanghai Bell | Noted |  |

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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tdoc number** | **Revised to** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-23xxxxx |  | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-23xxxxx |  | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-23xxxxx |  | LS on … | ZZZ | Agreeable, Revised, Noted |  |
|  |  |  |  |  |  |

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