3GPP TSG-RAN WG1 #112bis-e R1-23NNNN

e-meeting, April 17th – 26th, 2022

Agenda Item: 9.5.5

Source: Moderator(Ericsson)

Title: Feature Lead Summary #1 for Positioning for RedCap UEs

Document for: Discussion, Decision

# Introduction

This document summarizes the contribution submitted to A.I 9.5.5, positioning for RedCap UEs. the proposals are prioritized with [LOW][MEDIUM][HIGH] tags, with the intention that [HIGH] proposals are intended for online discussion during this meeting, and [MEDIUM] proposals could be discussed if time allows. [LOW] proposals are listed to collect views from companies and are typically consisting of proposals based on few contributions.

# General issues

## Reporting of measurements per hops [HIGH]

### Background

The issue of whether to report measurement per hop has been discussed for both UL bandwidth hopping [6,10,13,14,21] and downlink BW hopping[6,13, 14].

In [6, 10, 13,14], it is proposed to consider the case where only part of the transmitted hops (either UL or DL) are successfully received and therefore it is not possible to coherently combine all hops to form a wideband measurement. In this case, a “fallback measure” would be to revert to report measurements on a per-hop basis[14]. [6,21] also propose to indicate in the measurement report whether the reported measurement is made on a given hop, or using all hops. [10,13] mention the use of a “part index” or a “hop indicator” to be attached to the measurement to link a particular hop to the measurement.

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| **Company** | **Proposal** |
| [14] | Proposal 4: Study measurement procedure for SRS hopping or Rx hopping for timing and power measurements (e.g., RSTD, UE/gNB Rx-Tx time difference, RSRP), i.e., whether to make measurements on received RS based on coherently combined hops or per hop-basis |
| [6] | Proposal 5: For RedCap UEs positioning with UL frequency hopping, support a gNB to report the measurement to the LMF with single combined reporting and multiple per hop reportings.   * FFS: indicator for combined reporting/per hop reporting, with a value of 1 corresponding to combined reporting, with a value of 0 corresponding to per hop reporting. * FFS: whether and how the gNB/TRP reports the number of hops to the LMF. * FFS: the hop index for per hop reporting method.   Proposal 9: For RedCap UEs positioning with DL frequency hopping, support a UE to report the measurement to the LMF by use of combined reporting and per hop reporting method. |
| [10] | Proposal 3: support FH based reporting and associated FH part index within one complete PRS. |
| [13] | Proposal 4: For measurement report considering DL frequency hopping, UE should report the corresponding hop indication for each measurement result, where the hop indication includes the frequency range.  Proposal 10: Support that TRPs can report the corresponding hop indication for each measurement result. |
| [21] | Proposal 8: In frequency hopping for RedCap uplink positioning, the measurements are reported per hop, or a single measurement is reported after combining all the hops. |

### Round 1

We start discussing whether to support per-hop reporting. Regarding the FFS points mentioned by [6], from the FL perspective it would be more suitable to leave these the RAN2 and RAN3.

**Proposal 1.1-1: For DL Rx hopping or UL Tx hopping , support the UE or gNB to report the following:**

* **A measurement based on combining all hops**
* **One or more measurements where each measurement is associated with a single received hop.**

Comments can be entered in the table below:

**Proposal 1.1-1:**

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| --- | --- |
| **Company** | **comment** |
| CATT | Support.  We think both the single combined reporting and multiple per hop reporting should be supported. |
| vivo | Generally OK. For the 2nd sub-bullet, it can be changed as FFS after the application scenarios is clear. |
| InterDigital | We support the proposal in principle. Regarding the bullets, is it expected that both options (measurement for combined hops, measurement per hop) are reported simultaneously? |
| Huawei, HiSilicon | OK |
| NEC | Support in general.  For the second sub-bullet, we think measurement based on several consecutive hops but not all the hops should also be included. |
| ZTE | Support in general.  We would like to additional support UE or gNB to report a measurement based on some of the hops. For example, hop 4 and hop 5 may have collision with other UL/DL transmission/reception, a UE or gNB may still report a measurement based on combing hop {1,2,3}. Therefore, we recommend the following:  **Proposal 1.1-revised: For DL Rx hopping or UL Tx hopping of RedCap UE , support the UE or gNB to report the following:**   * **A measurement based on combining all hops** * **A measurement based on combining some of the hops** * **One or more measurements where each measurement is associated with a single received hop.** |
| SONY | Okay |
| mtk | For the measurement on each hop, UE may perform IFFT with same size on each hop. The number of IFFT operations increase but we don't see what is the benefit of doing so. We prefer to put SSF for 2nd sub-bullet |
| Nokia/NSB | Do we mean this applies to all types of measurements? We are not sure what the benefit of RSRP per hop is. If the UE can measure all/multiple hops then what is the benefit of reporting timing measurements on a single hop?  We agree with the comments above that a measurement based on combining some hops is worth considering. |
| Futurewei1 | Propose FFS for the second sub-bullet. |
| Qualcomm | A UE can always be possible to report a measurement based on a single hop (this is legacy behavior, and cannot be excluded). We agree with ZTE’s view that, in addiiton to the „all hops“ and „single hop“, it shoudl be allowed to report a measurement based on a subset of hops. |
| CMCC | Support. |
| IIT Kanpur, CEWiT | We Support the proposal |
| Intel | We are fine with the proposal in principle. |
| Apple | Fine with the proposal |

## Capabilities for Overlap between hops and number of hops [HIGH]

### Background

Signaling of a UE capability regarding the maximum number of hops for DL PRS Rx hopping is mentioned in [5, 12, 6, 8,13, 19,21]. [13] propose values between 2-5 hops. A similar capability for UL SRS hopping is discussed in [21, 20, 17 ]

In [5, 6,13,17, 19, 20, 21], the amount of overlap (or the support of overlap, for [20]) is also part of the capability. [21] proposes to report overlap between 1,2,4 or8 PRBs. [19] proposes to consider multiple of 4 PRBs for the overlap granularity, while [17] proposes to consider a minimum of 1 PRB. For the maximum value, [3] propose that the overlap size should be smaller than 8 PRBs. In[18], it is propose to make the overlap size a function of the channel quality.

In [21], the maximum bandwidth per hop is also part of the capability.

A few contributions mentioned the phase offset compensation. In [10,18], it is proposed to discuss further the phase compensation, while in [12], it is proposed to leave it to UE implementation. From the FL perspective, it seems suitable to leave the compensation technique to implementation. RAN4 will work on the requirements for the measurement reported with Rx hopping, and this will depend on the total bandwidth (and thus the total number of hops) as well as the amount of overlap between hops. How the UE uses the overlap to compensate the phase offset can be left to implementation.

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| **Company** | **Proposal** |
| [12] | Proposal 5: Specify the capability on the amount of Rx hops to combine, storing the number of time domain DL-PRS samples across different hops for coherent Rx combining to achieve wideband DL-PRS measurement for RedCap devices.  Proposal 2: Phase offset compensation should be left to UE implementation. |
| [6] | Proposal 6: For RedCap UE positioning with DL Rx frequency hopping, support the following UE capability: the number of overlapping frequency resources in adjacent hops and the number of hops (Alt 1). |
| [8] | Proposal 5: Support the UE capability parameter to reflect the supported frequency hopping operation for NR RedCap UE. (i.e, by considering the RedCap UE constraints / limitations). |
| [10] | Proposal 5: FFS how to compensate the impacts on phase offset and/or amplitude change, from the time varying channel property. |
| [13] | Proposal 1: With regards to frequency hopping for positioning for RedCap UE, the number of hops should be configured by the network:   * UE reports a capability on the maximum number of supporting frequency hops to network, the candidates are {2, 3, 4, 5} * UE reports a capability on the overlapping PRB(s) between adjacent hops or a capability on the maximum equivalent bandwidth after combing all hops |
| [21] | Proposal 3: For RedCap positioning, the number of hops, measurement bandwidth per hop, and overlapping bandwidth are UE’s capabilities to be reported to LMF.  Proposal 4: For RedCap positioning, the overlap of bandwidth between the adjacent hops is X PRB. The possible values of X are 1,2,4,8 PRB. |
| [11] | Proposal 5: To support RS frequency hopping, the partial overlapping in the frequency domain should be considered to mitigate the phase discontinuity between different hops. |
| [19] | Proposal 3:   * RAN1 should first agree to support the overlap between hops, and then discuss a UE capability related to overlap.   Proposal 4:   * If the number of overlapping frequency resources in adjacent hops is a UE capability, 4 PRBs overlap may be a reasonable starting point from the specification impact perspective.   + If the overlap size needs to be larger than 4 PRBs, it should be multiple of 4 PRBs. |
| [22] | **Proposal 3-1**: For the configuration for SRS transmission frequency hopping, UE may report the RF retuning capability, since the duration in terms of symbol number between the end of a hop and the start of next hop is related to the UE RF retuning capability |
| [20] | ***Proposal 6: For SRS for positioning frequency hopping configuration mechanism, following should be specified:***   * ***Switching mechanism for SRS-pos frequency hopping configuration*** * ***Configuration of overlap size*** |
| [17] | **Proposal 2: Support a UE to report a capability for the amount of overlap required for DL PRS and SRS for Positioning.**  **Proposal 3: Support in the specification multiple overlap options between 2 frequency-adjacent hops with a minimum value of 1 PRB.** |
| [3] | ***Proposal 2:***   * ***For the sizes of overlapping bandwidth for different hops, the balance between phase error compensation performance and bandwidth span of frequency hopping should be considered.*** * ***A size smaller than 8 PRBs can be considered*** |
| [5] | ***Proposal 7: The number of overlapping frequency resources in adjacent hops required for the UE to perform phase offset compensation the overlap between hop for DL PRS Rx frequency hopping is a UE capability.***  ***Proposal 8: For positioning for RedCap UEs, the number of hops for DL PRS Rx frequency hopping is a UE capability.*** |
| [18] | ***Proposal 4: To refine the overlapped bandwidth configuration among kinds of RedCap UEs, support RedCap UE reports the related parameters as a capability, such as level of phase offset between hops.***  ***Proposal 5: For frequency hopping of PRS, support size of overlapped bandwidth between two adjacent hops is decided by channel quality.*** |

### Round 1

There seem to be consensus from the proposals that there should be a capability for the number of hops, as well as overlap between hops, for both reception of the DL PRS with Rx hopping and transmission of the UL SRS with Tx hopping. The granularity for these capability could be discussed later during UE features. For the UL SRS, the proposals only included the overlap between hops and the bandwidth for each hop.

**Proposal 1.2a-1: For the reception of DL PRS with Rx hopping, the following are separate UE capabilities:**

**the overlap between hop for DL PRS frequency hopping**

* **FFS: granularity of the capability**

**the number of hops for DL PRS frequency hopping**

* **FFS: granularity of the capability**

**The maximum bandwidth in a hop**

* **FFS: granularity of the capability**

**Proposal 1.2b-1: For the transmission of UL SRS with Tx hopping, the following are separate UE capabilities:**

**the overlap between hop for UL SRS frequency hopping**

* **FFS: granularity of the capability**

**The maximum bandwidth in a hop**

* **FFS: granularity of the capability**

Comments can be entered in the tables below:

**Proposal 1.2a-1**

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| **Company** | **comment** |
| CATT | Support. |
| vivo | The details of PRS Rx hopping is up to RAN4, it is still not clear the impact of UE reporting these capabilities. In our view, the UE capability of Rx hopping can also be determined by RAN4 together with other Rx hopping details. |
| Huawei, HiSilicon | It is too early to discuss UE capabilities. What is the spec for those capabilities? |
| NEC | We agree with the maximum overlapped bandwidth as a kind of capability. For the actual overlapped bandwidth, associates with channel quality, positioning requirement is more reasonable, of which, base station may have a more accurate understanding. In addition, by comparing with leaving the overlapped bandwidth to be an implementation of RedCap UE, configured overlapped bandwidth reduces the complexity of measurement determination by using a definite configuration, rather than trying multiple possible sets of overlapped bandwidth to find the one with best performance. So, we think configurable overlapped bandwidth is beneficial. |
| ZTE | OK to postpone the discussion.  Generally we support that both the overlap between hops and number of hops should be UE capabilities. However, for the maximum bandwidth of a hop, no separate UE capability is needed. It can simply refers to the the existing UE capability. |
| SONY | Support |
| mtk | RX hopping is RAN4’s work |
| Nokia/NSB | Agree with Huawei. This should be low priority and discussed in future meetings. We should first agree that at least overlapping hops will be supported. |
| Futurewei1 | For DL PRS frequency hopping, the maximum bandwidth capability may not be needed if the number of hops is capability.  It is too early to discuss overlapping capability without knowing if overlapping is supported or not for DL PRS frequency hopping. |
| Qualcomm | There needs to be an agreeemnt on supporting „overlapping hops“, and it is related to how much will be the total BW that is being mesaured. If a UE needs significant overlap, then tthe total BW will be smaller. This will result to different expected behavior and performance.  At a minimum having a „principle agreement“ on a UE reporting related capability is needed. |
| CMCC | Postpone the discussion to future meetings. |
| IIT Kanpur, CEWiT | We Support the proposal |
| Intel | Although we understand the intention of the proposal, it seems to us it is a bit too early to discuss UE capability and that there are aspects here that need further progress in RAN4.  We also share similar view as other companies that maximum bandwidth in a hop would not be a part of UE capability. |
| Apple | We think that the overlap between hops for both DL and UL should be discussed in some additional detail. |

**Proposal 1.3b-1**

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| **Company** | **comment** |
| CATT | Support. |
| Huawei, HiSilicon | Why do we need the maximum bandwidth per hop as the capability? |
| NEC | Same comment as Proposal 1.2a-1. |
| ZTE | Similar as our comment for Proposal 1.2a-1, we are ok to introduce a separate UE capability for the overlap between hops and delete “**~~The maximum bandwidth in a hop~~**”. |
| SONY | Support |
| mtk | 1, not clear why overlapping between hops is UE capability. If the UE could switch RF, the next center frequency point could be anywhere  2, not clear why max BW per hop is also UE capability |
| Nokia/NSB | This should be low priority and discussed in future meetings. We should first agree that at least overlapping hops will be supported. |
| Futurewei1 | It is too early to discuss overlapping capability without knowing if overlapping is supported or not for UL SRS frequency hopping. Suggest to discuss SRS configuration first, namely overlapping, bandwidth per hop and the number of OFDM symbols per hop (i.e., dwell time per hop). |
| IIT Kanpur, CEWiT | We Support the proposal |
| Intel | Same comments as above. |
| Apple | Same as above |

## Switching time between hops (paused)

### Background

[14,12,8,10,22] have additional proposals with respect to the time gap between hops for either the SRS or the PRS. Since RAN1 has not yet received a response regarding the retuning time, it is proposed to pause the discussion until next meeting, when we will hopefully have a better view on what time gap between hop is suitable for both DL PRS Rx hopping and SRS Tx hopping.

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| **Company** | **Proposal** |
| [14] | **Proposal 1: Study dependency between the amount of overlapped bandwidth and gap between two consecutive frequency hops** |
| [12] | ***Proposal 6: Specify the timing offset resulting from the reception of different positioning hops.*** |
| [8] | Proposal 2: Introduce two parameters, Tgap (the time gap between two adjacent hops) and F\_ovl (the overlap resources in frequency domain), to facilitate bandwidth stitching in the frequency hopping operation.  Proposal 3: These parameters (T\_gap and F\_ovl) can be configured for each measurement occasion or semi-consistent for multiple occasions. |
| [10] | Proposal 4: a time gap configuration should be considered between hops, FFS the candidate value and applicable condition. |
| [22] | **Proposal 2-3**: The suitable UE capability for reception frequency hopping could consider RF retuning time, not the total measurable BW, since it could depend on the DL-PRS structure |

### Round 1

From the FL perspective, we should delay discussions related to the time gap between hops until RAN4 has responded to the RAN1 LS on switching time.

Comments can be entered in the table below:

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| **Company** | **comment** |
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## Hopping pattern [MEDIUM]

### Background

Multiple companies have discussed the hopping patterns for Rx and Tx hopping[8,13,21,3,17]. In [8], it is proposed to make the hopping pattern reconfigurable. In [13] it is proposed to ensure that the overlap between hops is such that the same Res are available from the two overlapping hops. [3] and [17] discuss a diagonal hopping pattern (where two consecutive hops always have an overlap), and [17] propose to also study hopping where overlap may not always be between consecutive hops.

In [7], it is proposed to let the gNB chose between a Redcap-UE only pattern and a pattern suitable to both redcap and non-redcap UEs. however, this seem to contradict the following conclusion from the last meeting:

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

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| **Company** | **Proposal** |
| [8] | Proposal 4: Further study whether the frequency hopping pattern is fixed or reconfigurable. |
| [13] | Proposal 9: In the overlapping PRB(s), support SRS transmission with comb size 1 for effective estimation of phase rotation. |
| [21] | Proposal 2: For UE-assisted Redcap positioning, bandwidth overlap between the adjacent frequency hops should be supported. |
| [3] | Proposal 1:   * Regarding frequency hopping pattern for RedCap positioning, the diagonal hopping pattern is supported.   Proposal 3:  • For channel stitching of the symbols from different hops, the same comb size and RE offset should be supported |
| [17] | Proposal 7: Study further at least the following two options for the SRS frequency hopping pattern:   * Option 1: Use the current hopping formula of SRS as a starting point and update it such that there can be frequency domain overlap over 2 hops that are adjacent in frequency.   + Example of the update in the frequency-domain starting position : * Option 2: Use a staircase-like hopping formula with a parameter that controls the amount of overlap of frequency domain adjacent hops. |
| [7] | Proposal 1   * For DL PRS for RedCap UEs, detailed frequency hopping pattern for the reception of DL PRS across different subbands is defined. * gNB may choose between the option of transmitting a single common DL PRS that may be received by RedCap and non-RedCap UEs and the option of transmitting DL PRS for RedCap UEs separate from that for non-RedCap UEs. |

### Round 1

It seems that at least the principle of overlap between consecutive hops is agreeable, with further discussion on how exactly to configure the hopping pattern for the SRS to be decided later.

**Proposal 1.4-1**

**For DL PRS rx hopping and UL SRS Tx hopping, the overlap in frequency is between two consecutive hops.**

**FFS: how to configure the overlap for UL SRS Tx hopping.**

Comments can be entered in the table below:

**Proposal 1.4-1**

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| --- | --- |
| **Company** | **comment** |
| vivo | The details of PRS Rx hopping are up to RAN4 and whether the overlap in frequency for DL PRS Rx hopping has RAN1 spec impact is not clear now. Therefore, in this stage, we propose to only support SRS hopping related overlapping. So, the proposal can be modified as  **Proposal 1.4-1**  **For ~~DL PRS rx hopping and~~ UL SRS Tx hopping, the overlap in frequency is between two consecutive hops.**  **FFS: how to configure the overlap for UL SRS Tx hopping.** |
| InterDigital | Support |
| Huawei, HiSilicon | What is the spec impact for this proposal? |
| NEC | Support in general. And to include the special case of overlapped bandwidth being zero, we suggest adding a note for this proposal.  Note: It doesn’t mean the overlapped bandwidth being zero is precluded. |
| mtk | 1, For DL PRS RX hopping, it is up to implementation  2, For UL SRS TX hopping, we are okay |
| Qualcomm | Does the „Two consecutive hops“ mean, „2 time-domain consecutive hops“ or frequency-domain hops? Some clarification is needed |
| CMCC | Support for SRS part, fine with vivo’s revision. |
| Intel | We are fine with the proposal. |
| Apple | Support this proposal. |

## Bandwidth limitation [MEDIUM]

### Background

3 companies had proposals regarding the bandwidth to consider for positioning of RedCap UEs. the previous meeting captured the following conclusion:

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| **Conclusion**  The scope for RedCap positioning includes FR1 and FR2. |

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| **Company** | **Proposal** |
| [12] | ***Proposal 3: Support Redcap PRS processing capability with reduced bandwidths e.g., 20MHz for FR1 and 100MHz for FR2 including a reduced Rx antenna/RF chain of a single antenna.*** |
| [1] | **Proposal 4: For improving the positioning accuracy of RedCap UEs, support transmit/receive frequency hopping for SRS and PRS with partial overlapping frequency resources for both FR1 and FR2.** |
| [4] | **Proposal 1: For RedCap UE positioning, the maximum DL/UL frequency hopping bandwidth should be limited to 100MHz at FR1.**  **Proposal 2: On frequency hopping for RedCap UE positioning, reuse the existing bandwidth part restriction for each hop, i.e. up to 20MHz at FR1 and 100MHz at FR2 per DL/UL BWP.** |

### Round 1

We can try to further detail the conclusion from the previous meeting by detailing the maximum supported hop bandwidth for each frequency range. Note that there is also a discussion for signalling a UE capability regarding the hop bandwidth in section 2.2.

**Proposal 1.5-1: for the positioning of redcap UEs, for the DL PRS reception and UL SRS transmission, the maximum hopping bandwidth for a single hop is 20MHz for FR1 and 100MHz with FR2.**

Comments can be entered in the tables below:

**Proposal 1.5-1**

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| --- | --- |
| **Company** | **comment** |
| vivo | OK |
| Huawei, HiSilicon | Support it as the conclusion. |
| NEC | Support. |
| ZTE | Agree with Huawei’s comment. The maximum hopping bandwidth for a single hop should refer to the maximum bandwidth supported for legacy RedCap UE. A simple conclusion is necessary. |
| Qualcomm | Support |
| CMCC | Support. |
| Intel | Fine with a conclusion. |
| Apple | Fine as conclusion. |

## Supported methods [LOW]

### Background

Three companies mentioned the methods to be supported by redcap positioning.

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| **Company** | **Proposal** |
| [12] | ***Proposal 1: Prioritize timing-based positioning technique such as TDoA, RTT for***  ***Redcap positioning.*** |
| [14] | **Proposal 3: Support both DL/UL timing and angle based positioning methods for hopping based positioning methods** |
| [9] | **Proposal 1**: RAN1 should discuss how to perform phase alignment between frequency chunks in PRS frequency hopping/stitching including the impacts of a poor channel on the overlapping RB/REs.  **Proposal 2**: RAN1 should support phase alignment for Multi-RTT and determine if phase alignment is needed for both UL at the gNB and DL at the UE. |

### Round 1

From the FL perspective, the WID does not specify a particular method to be supported. The topic was discussed during RAN1#112 but did not progress to an agreement due to differing views on including carrier phase positioning in the included methods. Since the issue is not critical to the progress of the other issues, it is propose to treat the proposal with low priority.

**Proposal 1.6-1:**

**Rel-18 positioning enhancements for RedCap UEs includes all RAT-dependent positioning methods supported in Rel-17.**

Comments can be entered in the table below:

**Proposal 1.6-1:**

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| **Company** | **comment** |
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## Requirements [LOW]

### Background

One company proposed to send an LS to RAN4 regarding the definition of RRM requirements.

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| **Company** | **Proposal** |
| [11] | Proposal 2: It is up to RAN4 to define RRM requirements for UE performing DL PRS Rx frequency hopping.  • A LS to RAN4 can be sent. |

### Round 1

From the FL perspective, the definition of RRM requirements by RAN4 once a feature is specified is business as usual for the RAN4 WG. An LS is not required to trigger this, thus we propose to not take further action on the issue.

Comments can be entered in the table below:

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| **Company** | **comment** |
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# DL-PRS Frequency Hopping

## Further configuration of Rx hopping for DL PRS [HIGH]

### Background

Several companies presented further proposals regarding the configuration of DL PRS RX hopping[2,5,8,15,16,18].

In [8] it is proposed to support hopping to be configurable across multiple PRS resources or resource sets, and thus reconsider the previous agreement to hop within a resource. The raised issue is the number of retuning/switches considering beam sweeping.

[5,15,16,18] propose to implement the Rx hopping using the DL PRS repetition scheme. [5] also mentions that hopping across resources could be considered, which would revert the previous agreement to focus on hopping within a DL PRS resource. [15] also points that the resource periodicity may need to have additional values, in order to support both beam sweeping and hopping. [16] proposes to consider sub-slot repetitions to lower the Rx hopping overall latency when possible.

[18] proposes to configure the overlap to use by the UE when performing Rx hopping.

[18] propose to consider configuring lower SCSs in order to improve performance for low speed UEs.

[2] proposes to pause the discussion until a response from RAN4 on the retuning time has been received.

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| **Company** | **Proposal** |
| [8] | Proposal 9: Support frequency hopping is configurable across multiple DL PRS resources or resource-sets. |
| [5] | Proposal 1: UE perform frequency hopping reception between different PRS transmission repetitions within one period of one PRS resource can be considered.  Proposal 2: UE performs frequency hopping reception of PRS between PRS resources can be considered. |
| [18] | Proposal 1: Repetition scheme for PRS can be considered to realize DL PRS frequency hopping in Rx.  Proposal 2: For frequency hopping of PRS, support configurable overlapped bandwidth between two adjacent hops to address the influence caused by phase offset between hops.  Proposal 3: For frequency hopping of PRS, support presence of overlapped bandwidth between two adjacent hops associates with the level of phase offset between hops.  Proposal 9: Consider using small SCS to increase the positioning performance for RedCap UEs with low speed at least. |
| [15] | Proposal 1: For DL PRS Rx Hopping, the UE hops within a DL PRS resource. The specification impact includes the following:   * Frequency domain: no change * Time domain: increase number of repetitions to enable mapping over BW. This may need an update to parameters like the L-PRS-ResourceRepetitionFactor, DL-PRS-ResourceTimeGap and the DL-PRS-Periodicity. |
| [2] | Proposal 2: RAN1 should wait the reply LS from RAN4 for further discussion on PRS Rx hopping reception. |
| [16] | Proposal 1 Inter-slot PRS frequency hopping can be implemented without RAN1 specification impact.  Proposal 2 Send an LS to RAN4 requesting to consider measurements based on intra-slot hopping for RedCap UEs.  Proposal 4 Support sub-slot (symbol) level repetitions, with resource time gap using symbol resolution. |

### Round 1

From the FL perspective, it is preferable to avoid reopening closed issues from the previous meeting, and therefore hopping across resources as proposed in [5,8] is not considered at this stage, unless a serious issue is identified.

Regarding the configuration of the overlap proposed in [18], the motivation is unclear. The UE should be able to use any overlap in Rx hopping, provided it can deliver the measurement quality set by the RAN4 requirements. RAN2/RAN4 could discuss the need for assistance data for the requirement. Similarly, the configuration of different SCSs as proposed in [18] seem an implementation issue.

Thus, the following proposal focuses on configuration of the repetition framework to support Rx hopping. The FFSs list the potential inpact on repetition factor and periodicity configuration.

**Proposal 2.1-1: Rx hopping of the DL PRS is supported using DL PRS repetitions of a DL PRS resource**

* **FFS: additional values to the repetition factor configured in D*L-PRS-ResourceRepetitionFactor* and periodicity in *DL-PRS-Periodicity***
* **FFS: additional values to the resource time gap configured in *DL-PRS-ResourceTimeGap*, including support for sub-slot repetitions.**

Comments can be entered in the table below:

**Proposal 2.1-1**

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| **Company** | **comment** |
| CATT | Support the proposal. |
| vivo | We are generally OK for the main bullet. But we have some concern on the last FFS, considering the UE may measure the PRS resource from multiple TRP for each hop, the benefit and performance of intra- slot repetition is unclear. |
| InterDigital | Is this discussion related to the definition of “DL PRS Rx hopping sequence” in 3.3? |
| Huawei, HiSilicon | Up to RAN4. |
| NEC | Support. |
| ZTE | We believe this proposal is highly related to the conclusion of RAN4, if eventually the switching gap is less than 1 ms, then both inter-slot Rx hopping of DL PRS and intra-slot Rx hopping of DL PRS can be supported, where:   * Inter-slot Rx hopping of the DL PRS is supported using DL PRS repetitions of a DL PRS resource * Intra-slot Rx hopping of the DL PRS is supported by implementation (e.g. DL PRS can be configured with comb size 2 and symbol number 12 in a slot. Then symbols {3,4} are a repetition of symbols {1,2} and naturally intra-slot hopping can be supported). |
| SONY | Support |
| mtk | 1, we would consider it is up to RAN4. Because if a UE has short RF switch time, the UE could also hop within a resource with large symbol number, for example when comb-4 with 12 symbols being configured. UE could measure in the first 4 symbols, hop in second 4 symbols and further measure in last 4 symbols. |
| Nokia/NSB | Hard to agree on the main bullet prior to RAN4 decision. Might be better to directly discuss what enhancements are really needed (i.e., details of the FFS points). |
| Futurewei1 | It is too early to discuss the details of DL PRS repetition without knowing configuration parameters such as the switching time from one hop to another. |
| Qualcomm | We think that the hopping could happen within a single repetition also (e.g. 12-symbol PRS pattern with comb-4, there are 3 fully-staggered patterns. A UE could measure the first and the last with a retune in between. It may be related to the RAN4’s agreement on the retuning time.  Overall, we agree with ZTE’s proposal. |
| CMCC | We think that it should be up to RAN4, at least we should wait for the LS reply from RAN4. |
| IIT Kanpur, CEWiT | We Support the proposal |
| Intel | We understand the intention, but it would be good to wait for the progress in RAN4 before we can make a decision on this. |
| Apple | Support |

## Partial staggering / number of symbols restrictions [LOW]

### Background

[16] propose to consider partially staggered PRS patterns, and [12] to introduce restriction on the number of PRS symbol length.

|  |  |
| --- | --- |
| **Company** | **Proposal** |
| [12] | ***Proposal 4: Support only longer PRS symbol lengths for RedCap devices {6,12} and FFS support PRS symbol lengths of {2, 4}.*** |
| [16] | Proposal 3 Support partially staggered PRS patterns. |

### Round 1

Regarding support of partial staggering, TEI18 introduces the support of 1-symbol PRS. From the FL perspective, there does not seem to be any restriction to the 1-symbol PRS to non-redcap UEs. therefore, if the feature is signalled as supported by a redcap UE, it could potentially be used.

Regarding restriction on the symbol length, it may not be required to be specified, as it could symbol stem from the constraints on retuning time.

It is therefore proposed to not further discuss these issues. Please leave a comment in the table below if needed.

|  |  |
| --- | --- |
| **Company** | **comment** |
|  |  |

## Use of one or more MGs for reception of DL PRS with rx hopping, processing capability [HIGH]

### Background

During RAN1#112, we discussed the use of measurement gaps (MGs) for DL PRS Rx hopping. Use of a single or several gaps in the Rx hopping procedure was left FFS:

|  |
| --- |
| **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 |

Single-MG solutions are supported by [5,6,8,13,17,19]

Multiple-MG is mentioned to be at least considered in [17][15][18]

In [3], it is propose to request feedback from RAN4 on the issue of using one or multiple MGs during FH.

Defining a new UE DL PRS Rx processing capability is discussed in [8,15,18] .

|  |  |
| --- | --- |
| **Company** | **Proposal** |
| [6] | Proposal 7: For RedCap UE positioning with Rx frequency hopping, support a single instance of a MG. |
| [8] | Proposal 8: For RedCap UE positioning, only support the use of a single instance of MG for DL PRS with Rx frequency hopping.  Proposal 6: Support the RedCap UE’s processing time for Rx frequency hopping as part of the UE capability. |
| [13] | Proposal 2: To ensure positioning performance, a single MG instance is used for PRS measurement of all hops. |
| [19] | Proposal 1:   * RAN1 should support a single instance of a MG for DL PRS FH. |
| [22] | Proposal 2-1: The reception frequency hopping across gap instances for the combination to acquire a larger measurement BW is not considered. If it is supported, there should be a signaling to indicate to NW  Proposal 2-2: Support the reception frequency hopping in each gap instance for the combination to acquire a larger measurement BW |
| [17] | Proposal 4: Support a MG-based DL-PRS frequency hopping approach in which the UE is expected to perform up to N Rx Retunings during a single MG instance in order to measure multiple frequency parts of a single PRS resource, with N = [4].   * FFS: the case of hopping across multiple instances of a MG |
| [1] | Proposal 1: For RedCap UE with DL PRS Rx hopping, RAN1 to discuss measurement gap length. |
| [3] | Proposal 4:  • For MG-based Rx frequency hopping, send an LS to RAN4 to determine one of the following methods and study detailed MG design  - One MG instance for multiple hops  - One MG instance for one hop  Proposal 5:  • For MG-based PRS Rx frequency hopping, detailed Rx hopping behavior within MG depends on RRM requirement, which is up to RAN4. |
| [5] | Proposal 4: UE can only apply a single instance of a measurement gap to complete one PRS frequency hopping reception. |
| [18] | Proposal 6: Whether all the frequency hops are included in a single measurement gap or multiple measurement gaps, is determined by the measurement gap configuration and the PRS processing capability of RedCap UE. |
| [15] | Proposal 2: Additional design details DL PRS Rx Hopping are as follows:   * Time domain repetition may have to account for the hops across the bandwidth as a single repetition is over multiple hops. * The muting pattern may either mute a single hop or may mute a hop set. * The measurement gap may have to accommodate the duration of the hop set. This may be accommodated by a single large MG or multiple instances of a MG. * Gapless measurements based on the PRS Processing Window (PPW) should be lower priority.   Proposal 4: A reply from the RAN4 LS is needed to update the existing sets of values for the UE DL PRS processing capability. |

### Round 1

There is a majority support for the support of a single gap covering the whole DL PRS Rx FH reception. However, it seems appropriate to request further feedback from RAN4 on the feasibility of a single gap before committing to a single gap to be used, since measurement gaps are within RAN4 specifications.

Therefore, we propose to start the discussion with the proposal to request RAN4 to consider single or multiple measurement gaps.

Regarding the processing capability for gap-based measurements, we will probably discuss extensively the issue during the UE feature discussion. A proposal to declare a separate feature for PRS processing with Rx FH is given below.

**Proposal 2.3a-1: For DL PRS Rx hopping using measurement gap(s), send an LS to RAN4 requesting the following**

* **For a given DL PRS with hopping, whether a single measurement gap or multiple measurement gaps may be configured configured to overlap with at least 1 DL PRS hopping sequence**

**Proposal 2.3b-1: For DL PRS Rx hopping using measurement gap(s), DL PRS processing for Rx frequency hopping is a UE capability**

* **FFS: details of the capability.**

Comments can be entered in the tables below:

**Proposal 2.3a-1:**

|  |  |
| --- | --- |
| **Company** | **comment** |
| CATT | Since the majority supports a single gap covering the whole DL PRS Rx FH reception, we prefer to try a single gap for the consensus. And we can inform the conclusion to RAN4 for confirmation.  Therefore, we prefer the following updated proposal:  **Updated Proposal 2.3a-1: For DL PRS Rx hopping using measurement gap(s), ~~send an LS to RAN4 requesting the following~~**   * **For a given DL PRS with hopping, ~~whether~~ a single measurement gap ~~or multiple measurement gaps may~~ should be configured ~~configured~~ to overlap with at least 1 DL PRS hopping sequence** * **Send an LS to RAN4 to check if there is any issue to support the above enhancement.** |
| vivo | Okay with FL proposal, but remove ”configured to overlap ” after may be configured in the sub-bullet |
| InterDigital | We suggest to change “DL PRS with hopping” => “DL PRS Rx hopping“. If the intention of “DL PRS hopping sequence” is “DL PRS RX hopping sequence”, there is a need to define what an Rx hopping sequence is. |
| Huawei, HiSilicon | No need for the LS. This is exactly RAN4 RRM scope. |
| NEC | We think RAN4 may cannot determine it directly, because it should consider the switching gap length, number of hops, measurement gap length, PRS processing capability simultaneously. |
| ZTE | In our understanding, as long as the length of a MG instance is long enough, a single MG instance can cover all the DL PRS hops. |
| mtk | We also don't consider to send LS |
| Nokia/NSB | Agree with Huawei. We can also wait for RAN4 to determine switching times prior to decided if single MG can be supported. |
| Futurewei1 | This depends on the dwell time of “1 DL PRS hopping sequence”, the number of hops, and switching time from one hop to another. |
| Qualcomm | We support CATT’s update. |
| CMCC | It should be up to RAN4. |
| IIT Kanpur, CEWiT | We Support the proposal |
| Intel | The need to send LS to RAN4 is not clear. Share similar view as HW. |

**Proposal 2.3b-1:**

|  |  |
| --- | --- |
| **Company** | **comment** |
| CATT | Support |
| Huawei, HiSilicon | No need to discuss it in RAN1. Any capability pertaining to DL PRS processing should be decided by RAN4 RRM. |
| NEC | Support. |
| ZTE | Support |
| SONY | Support |
| Nokia/NSB | Agree with Huawei. |
| IIT Kanpur, CEWiT | We Support the proposal |
| Intel | Share similar view as HW |

## Gap-less measurements / PPW for DL PRS with frequency hopping [HIGH]

### Background

Support of PPW with PRS Rx hopping was discussed during the previous meeting, and further input are given in the contributions.

In [6,9, 10,14,17], it is proposed to support PPW to received the PRS with Rx hopping.

In [2,3,5,7, 8,11,13,15,16,19,20,22], PPW is not supported.

In[3], it is proposed to consider the PPW when frequency hopping is not used.

|  |  |
| --- | --- |
| **Company** | **Proposal** |
| [14] | Proposal 2: Support PRS processing window to receive PRS via Rx hopping |
| [6] | Proposal 8: For RedCap UE positioning with DL Rx frequency hopping, support the use of PPW, e.g., one/multiple PPW based BWP frequency retuning method. |
| [8] | Proposal 7: Down-prioritize the frequency hopping operation within a PRS Processing Window (PPW) for RedCap UE. |
| [10] | Proposal 1: PPW only with PRS as higher priority could to be used for PRS Rx FH. |
| [13] | Proposal 3: De-prioritize PPW for RedCap UE with PRS frequency hopping measurement. |
| [11] | Proposal 1: For RedCap UEs, the PPW-based DL PRS measurement with Rx frequency hopping should be treated as low priority. |
| [19] | Proposal 2:   * RAN1 may not need to support PPW with FH. |
| [22] | Proposal 2-4: The use of PPW for positioning measurements for RedCap UEs is not considered |
| [20] | Proposal 1: Deprioritize DL-PRS frequency hopping outside MG. |
| [17] | Proposal 5: Support Rx frequency hopping for MG-less PRS processing using the following principle as a starting point:   * A UE may perform Rx frequency hopping within a PPW instance under the condition that the required retune time before and after each hop is taken into account in the specified PRS prioritization/collision rules.   + E.g. If the retune time before or after a low-priority PRS hop collides with a high-priority channel, then the UE does not perform the Rx frequency hopping. * FFS: Details including relation to the Rx frequency hopping with the PPW types |
| [3] | Proposal 6:  • For PRS Rx frequency hopping, PPW-based method is not supported.  Proposal 9  • For RedCap positioning without frequency hopping, the following aspects related to PPW should be further considered.  - The type of PPW can be limited to Type 1A and Type 2.  - The collision rules between PPW and UL transmission for a half-duplex UE (HD-UE) in FDD. |
| [5] | Proposal 3: Only measurement gap based measurement for DL PRS frequency hopping should be considered. |
| [9] | Proposal 3: Unless a critical issue is identified, RAN1 should support DL PRS frequency hopping outside MG for RedCap UE.  Proposal 4: RAN1 should specify solutions to effectively support DL PRS frequency hopping within PPW configurations. |
| [7] | Proposal 2   * For DL PRS with Rx frequency hopping for RedCap UEs, only MG based measurement is supported. |
| [15] | Proposal 2: Additional design details DL PRS Rx Hopping are as follows:   * Time domain repetition may have to account for the hops across the bandwidth as a single repetition is over multiple hops. * The muting pattern may either mute a single hop or may mute a hop set. * The measurement gap may have to accommodate the duration of the hop set. This may be accommodated by a single large MG or multiple instances of a MG. * Gapless measurements based on the PRS Processing Window (PPW) should be lower priority. |
| [2] | Proposal 1: Do not further consider MG-less/PPW-based scheme for PRS Rx frequency hopping for the target UE. |
| [16] | Proposal 5 PPW is not supported with DL PRS Rx hopping. |

### Round 1

Based on the majority, we propose to downprioritize the support of PPW. Regarding the support of PPW for PRS without Rx hopping as proposed in [3], from the FL perspective, this should be possible already if a redcap UE reports the rel17 feature.

**Proposal 2.4-1: (for conclusion) for RedCap UEs, measurements on DL PRS with frequency hopping using PPW (gapless measurements) are not supported.**

Comments can be entered in the table below:

**Proposal 2.4-1:**

|  |  |
| --- | --- |
| **Company** | **comment** |
| CATT | Do not support.  We prefer to further discuss DL PRS with frequency hopping using PPW, in order to increase the complexity of configuration of DL PRS with frequency hopping.  In PPW, the priority of different signals can be defined and configured, which is a significant advantage of PPW compared with MG. |
| vivo | Support |
| InterDigital | Our preference is to support the PPW. Since a priority level can be associated with PRS, a PPW for Rx hopping is beneficial so the UE can prioritize between making measurements of PRS and processing of other DL channels. |
| Huawei, HiSilicon | Support. |
| NEC | Support. |
| ZTE | Support. |
| SONY | Support |
| mtk | Support the proposal |
| Nokia/NSB | Do not support. For the companies that do not want to support DL FH with the PPW can they explain the technical concern? It is really weird for us to say that a Rel-17 feature can’t be implemented with RedCap devices which want to support high accuracy positioning at this stage already. |
| CMCC | Support. |
| Intel | Support |
| Apple | Okay |

## PRS reception for HD-FDD (paused)

### Background

In [6,3,7], the issue of collision with HD FDD are discussed for both the DL PRS and UL SRS.

|  |  |
| --- | --- |
| **Company** | **Proposal** |
| [6] | Proposal 3: For RedCap UEs positioning in HD-FDD, collision handling rules for UL SRS-Pos transmission and DL reception should be defined.  Proposal 10: For RedCap UEs positioning in HD-FDD, collision handling rules for DL PRS and other UL signals/channels within PPW should be defined, e.g., by the following two methods.   * Method 1: Reuse collision handling rule for DL PRS and other DL signals/channels in PPW in Rel-17, with new definition of PPW types (Type 3/4). * Method 2: Reuse the collision handling rule for other DL signals/channels and UL signals/channels for RedCap UE in HD-FDD. |
| [3] | Proposal 9   * For RedCap positioning without frequency hopping, the following aspects related to PPW should be further considered. * The type of PPW can be limited to Type 1A and Type 2. * The collision rules between PPW and UL transmission for a half-duplex UE (HD-UE) in FDD. |
| [7] | Proposal 6  • For HD-FDD RedCap UE, collision handling between DL PRS and UL channels/signals within a configured positioning processing window outside the measurement gap needs to be addressed. |

### Round 1

Regarding the collision of DL PRS with UL signals in HD-FDD redcap UEs, we propose to wait on the decision to support the PPW before introducing further proposals on collision rules. For the UL SRS, the discussion is grouped with the other collision rules discussion in section 4.3.

Comments can be entered in the table below:

|  |  |
| --- | --- |
| **Company** | **comment** |
|  |  |

## Assistance data for PRS with Rx hopping [LOW]

### Background

In [13], it is proposed to consider sending the number of hops, overlap and total bandwidth between hops to the UE as assistance data.

|  |  |
| --- | --- |
| **Company** | **Proposal** |
| [13] | Proposal 5: For PRS reception with hopping, one or more of the following parameters in assistance data should also be introduced to facilitate UE’s PRS measurement.   * + - * Number of hops       * Number of overlapped RB between hops       * Total bandwidth of all hops |

### Round 1

Since only 1 company has raised each of the issues above, let’s first collect some comments on the proposals to see the level of support.

Comments can be entered in the table below:

|  |  |
| --- | --- |
| **Company** | **comment** |
| InterDigital | Does this discussion relate to the definition of an Rx hopping sequence (AI 3.3)? |

## On demand DL PRS with hopping [LOW]

### Background

In [6,13], the support of on-demand PRS is proposed.

|  |  |
| --- | --- |
| **Company** | **Proposal** |
| [6] | Proposal 11: Support a RedCap UE to use an on-demand method to provide the recommended PPW-related configuration information to the network (serving gNB/LMF). |
| [13] | Proposal 6: For on-demand PRS, a RedCap UE can request a larger bandwidth that the UE supports, which implies PRS frequency hopping measurement is requested. |

### Round 1

Since only 2 companies has raised each of the issues above, let’s first collect some comments on the proposals to see the level of support.

Comments can be entered in the table below:

|  |  |
| --- | --- |
| **Company** | **comment** |
|  |  |

## Muting patterns for DL PRS with FH [LOW]

### Background

In [18, 15] it is proposed to study further enhancements for the muting framework to support DL PRS with FH.

|  |  |
| --- | --- |
| **Company** | **Proposal** |
| [18] | Proposal 7: For NR RedCap UEs, study the muting mechanism for frequency hopping sub-bands.  Proposal 8: For NR RedCap UEs, separate muting options configured for each hop is slightly preferred due to the flexibility on resource allocation. |
| [15] | Proposal 2: Additional design details DL PRS Rx Hopping are as follows:   * Time domain repetition may have to account for the hops across the bandwidth as a single repetition is over multiple hops. * The muting pattern may either mute a single hop or may mute a hop set. * The measurement gap may have to accommodate the duration of the hop set. This may be accommodated by a single large MG or multiple instances of a MG. * Gapless measurements based on the PRS Processing Window (PPW) should be lower priority. |

### Round 1

Muting was not discussed during the SI phase, and no recommendation to extend the muting framework was captured. Therefore, we propose to start the discussion with checking the support for the proposals above.

Comments can be entered in the table below:

|  |  |
| --- | --- |
| **Company** | **comment** |
| NEC | Muting pattern by considering hop configuration is beneficial for spectral efficiency. |

## Impact of DL PRS with FH on RACH [LOW]

### Background

|  |  |
| --- | --- |
| **Company** | **Proposal** |
| [10] | Proposal 2: RAN1 to study the impact of RACH related signal to the PRS Rx reception FH. |

### Round 1

Since only 1 company has raised each of the issues above, let’s first collect some comments on the proposals to see the level of support.

Comments can be entered in the table below:

|  |  |
| --- | --- |
| **Company** | **comment** |
|  |  |

# UL-SRS Frequency Hopping

## SRS Hopping configuration [HIGH]

### Background

During RAN1#112, we agreed to support SRS Tx hopping, with details to be worked out on how to configure it:

|  |
| --- |
| **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 |

In[1,2,6,7,9,15,16,17,19], it is propose to implement SRS Tx hopping within a UL SRS resource

In[3,4,5,13,15], companies instead propose to use hopping across resources

* [4] also mentions hopping across BWPs.

In [22], hopping is across SRS resource sets, and each resource correspond to a different beam.

In [20], a separate configuration from the exisiting SRS-pos configuration is proposed. [2] also proposes to consider the MIMO SRS.

Regarding the use of BWPs to configure hopping, [11] proposes to consider either a single BWP broader than the active BWP maximum size for redcap UE, or a set of BWPs.

|  |  |
| --- | --- |
| **Company** | **Proposal** |
| [6] | **Proposal 1: For positioning for RedCap UEs with UL SRS-Pos Tx Hopping, the UE hops within a UL SRS-Pos resource.** |
| [13] | Proposal 7: For RedCap UE, support frequency hopping across SRS resources. |
| [11] | Proposal 3: For RedCap UEs, consider the following enhancement on BWP configuration to support SRS for positioning frequency hopping:  • Alt. 1: Define a virtual UL BWP which is outside of RedCap UE active BWP limitation;  • Alt. 2: Define a BWP set consisting of multiple BWPs. The total number of BWP and BWP set for a UE is up to 4.  Proposal 4: For RedCap UEs, consider the following enhancements on SRS for positioning configuration to support frequency hopping:  • Alt. 1: Frequency hopping is configured for a given SRS for positioning resource.  • Alt. 2: Frequency hopping is configured for a given SRS for positioning resource set.  • Alt. 3: Frequency hopping is configured across multiple SRS for positioning resource sets. |
| [19] | Proposal 5:  • LS reply from RAN4 regarding the switching time values should be taken into account, and considering that RAN1 agreed DL PRS Rx hopping within a DL PRS resource at the last meeting, RAN1 should discuss further to support UL SRS hopping within a SRS resource depending on the switching time values. |
| [22] | **Proposal 3-7**: It is feasible to have a particular SRS resource set for hopping purpose in which each resource has the associated beam direction, and each resource could be associated with several different starting RB locations in different time instances. The resource transmitting in different starting RB locations has the same transmission power and the same transmission direction |
| [20] | Proposal 4: As parameter configuration method for determining the frequency hop of the SRS for positioning, the following alternatives can be considered.   * Alt. 1) Separately configured with SRS-Pos configuration. * Alt. 2) Jointly configured with SRS-Pos configuration.   Proposal 5: The intra-slot + inter-slot SRS-pos Tx hopping mechanism should be considered. |
| [17] | **Proposal 6: For SRS for Positioning frequency hopping:**   * **Define SRS for positioning associated with a CC (and not an active BWP) with each own numerology and bandwidth (e.g. similar to the SRS for Positioning of Rel-17 RRC inactive feature).** * **Introduce a transmission/switching/retune gap before and after a transmission of such an SRS resource.** |
| [1] | **Proposal 2: For RedCap UE Tx frequency hopping is configured within one SRS resource, RAN1 should clarify which one or both of the following possible alternatives:**  **Alt 1: One SRS resource spanning the instantaneous bandwidth**  **Alt 2: One SRS resource spanning the total frequency hopping bandwidth** |
| [3] | **Proposal 7:**  **• SRS for positioning frequency hopping configured across SRS resources is supported, including the following.**  **- Hopping is configured across multiple SRS resource set/resource lists**  **- Each SRS resource set/resource list is associated with a hop, and each hop includes a SRS resource set/resource list.**  **- Each SRS resource set/resource list is configured with a ‘virtual BWP’, similar to the ‘BWP configuration’ of SRS outside initial BWP in RRC\_INACTIVE** |
| [4] | **Proposal 3: For RedCap UEs positioning, support the SRS frequency hopping across multiple BWPs with multiple SRS resources.** |
| [5] | ***Proposal 5: SRS hopping between SRS resources should be supported.*** |
| [9] | **Proposal 5:** RAN1 should support SRS for positioning frequency hopping within an SRS resource, where the SRS resource configuration is separate from the existing UL BWP configuration.  **Proposal 6**: When UE is FH within an SRS resource it should transmit part of the SRS resource/sequence (i.e., 1 SRS frequency hop) during one hop. |
| [7] | **Proposal 3**   * For SRS for positioning with frequency hopping for RedCap UEs, * Frequency hopping is configured within an SRS resource. * SRS resource set is configured within a carrier. |
| [15] | ***Proposal 3: To support SRS for positioning frequency hopping, the hopping configuration need to identify the number of hops, the bandwidth of each hop, and the amount of overlap between hops. The hopping can be configured within an SRS resource or across resources. Both cases require an update to the existing configuration***. |
| [2] | ***Proposal 3: Following Rel-17 Option 2 of SRS for positioning transmission in RRC\_INACTIVE, SRS transmission in a frequency hopping way outside the initial UL BWP is supported for RedCap UEs.***  ***Proposal 4: Support SRS transmission outside the active UL BWP to support SRS Tx hopping based positioning of RedCap UEs in RRC\_CONNECTED state.***  ***Proposal 6: Study the enhancement of pos-SRS configuration to achieve SRS Tx frequency hopping within an SRS resource, e.g., introducing the frequency/time domain offset between adjacent hops, the number of hops*** ***for a single transmission occasion.***  ***Proposal 7: Subject to UE capability, within a larger BWP with bandwidth beyond maximum RedCap UE bandwidth to achieve SRS Tx frequency hopping, MIMO SRS can also be configured.*** |
| [17] | Proposal 7: Study further at least the following two options for the SRS frequency hopping pattern:   * Option 1: Use the current hopping formula of SRS as a starting point and update it such that there can be frequency domain overlap over 2 hops that are adjacent in frequency.   + Example of the update in the frequency-domain starting position : * Option 2: Use a staircase-like hopping formula with a parameter that controls the amount of overlap of frequency domain adjacent hops. |

### Round 1

We can start the discussion using the majority support option, which is to configure the SRS Tx hopping within a resource, and in a separate configuration from the active BWP, similar to the SRS config in RRC inactive. For the details on how to configure the hopping pattern, see section 4.2 discussion:

**Proposal 3.1-1: for RedCap UEs, SRS for positioning Tx frequency hopping is configured separately from the SRS configuration in the active BWP, similarly to the SRS configuration for RRC\_INACTIVE**

* **SRS Tx hopping is configured within the SRS resource.**
* **FFS: details on how to configure the hopping pattern, e.g. modify the equation for legacy FH or define a new hopping formula**
* **FFS: support of inter or intra slot FH**
* **FFS: support of the MIMO SRS with SRS Tx frequency hopping for redcap UEs.**

Comments can be entered in the table below:

**Proposal 3.1-1:**

|  |  |
| --- | --- |
| **Company** | **comment** |
| CATT | We support the SRS Tx hopping is configured within the SRS resource. And how to configure the SRS Tx hopping had better to listed as FFS.  Therefore, we prefer the following revision:  **Updated Proposal 3.1-1: for RedCap UEs, SRS for positioning Tx frequency hopping is configured within the SRS resource. ~~separately from the SRS configuration in the active BWP, similarly to the SRS configuration for RRC\_INACTIVE~~**   * **FFS :SRS Tx hopping is configured separately from the SRS configuration in the active BWP, similarly to the SRS configuration for RRC\_INACTIVE ~~within the SRS resource~~.** * **FFS: details on how to configure the hopping pattern, e.g. modify the equation for legacy FH or define a new hopping formula** * **FFS: support of inter or intra slot FH** * **FFS: support of the MIMO SRS with SRS Tx frequency hopping for redcap UEs.** |
| vivo | OK with the main-bullet of FL proposal. However, we have concerns about the first sub-bullet for hopping configured within an SRS resource.  Firstly, the concept of SRS Tx hopping is configured within the SRS resource is unclear. For example, different hops are different symbols of SRS resource, or different hop are different repetitions of SRS resources.  Secondly, different from DL PRS, there is no repetition configuration in SRS resource configuration. So, if different hops are different symbols of SRS resource, SRS Tx hopping is configured within the SRS resource may require UE complete the hopping within a slot. And it may introduce the huge impaction for specification. But before the receiving the response of LS from RAN4, it is difficult to confirm the UE can complete the hopping within a resource in a slot.  In addition, for SRS frequency hopping, either SRS hopping within an SRS resources or SRS hopping within SRS resource sets can work. So, for the issue, we prefer to list all the option and decide it based on RAN4 response in the next meeting |
| InterDigital | We support the proposal in principle. We don’t see a need to include “similarly to the SRS configuration for RRC\_INACTIVE” since we are not sure if there will be commonalities between SRS design for RRC\_INACTIVE and Tx frequency hopping. If the intention is to emphasize that a separate SRS config from the config in active BWP, “for RedCap UEs, SRS for positioning Tx frequency hopping is configured separately from the SRS configuration in the active BWP” is sufficient. |
| Huawei, HiSilicon | OK in general. |
| ZTE | We agree with vivo’s understanding and we still prefer SRS Tx hopping configured across SRS resources.  SRS hopping within one resource may have less flexibility since the current SRS configuration for each resource is only limited to one slot, and then the SRS hopping is limited to intra-slot hopping case only. |
| mtk | It seems that both hopping within a resource, or hooping within a resource set work. To hop within a resource may limit the hopping within a slot.  It seems to be more okay to hop within a resource set and it can be across consecutive slots |
| Nokia/NSB | What does the main bullet actually give us over the prior agreement? We already agreed to have a configuration separate from BWP configuration. So we don’t see the need to discuss that part at all here. The key is hopping in a resource or across resources.  From our side we support hopping within a resource. |
| Futurewei1 | RAN1 should clarify the concept of SRS Tx hopping is configured within the SRS resource. Based on our understanding, there are multiple interpretations as follows:  Alt 1: One SRS resource spanning the instantaneous bandwidth  Alt 2: One SRS resource spanning the total frequency hopping bandwidth  It is too early to decide whether intra- or inter-slot, which depends on other configuration parameters such the number of hops, and switching time from one hop to another. |
| CMCC | We are OK with the main bullet but think it is pre-mature to only say support of configuring SRS Tx hopping within a resource. Suggest to list all the options. |
| Intel | We are generally fine with the proposal in principle. We also prefer to configure SRS frequency hopping within an SRS resource. The update from CATT align with our view.  For the last FFS: we do not think we need to discuss MIMO SRS in this AI. It is clearly out of scope. The use of MIMO SRS for the purpose of positioning has been motivated by its transparency to the UE. Introducing Tx FH for MIMO SRS for a RedCap UE would certainly violate that and thus, outside the scope of the WI. |
| Apple | Fine with main bullet. |

## Parameters to configure frequency hopping for SRS tx hopping [medium]

### Background

Several contributions provided further details as to how to configure the hopping patterns for the SRS, using a combination of ovelap, time gap, number of hops or total target bandwidth. Note that there is a dependency on the high level configuration discussion in section 4.1, thus we should treat this issue once we progress in the issue in 4.1.

In [6,9], it is proposed to configure the overlap, starting PRB, time between hops and number of hops

In [7,15,13,20], the overlap is not configured and instead implied by configuration of the starting PRB and the hopping bandwidth for each hop.

In [17], the overlap and hopping bandwidth are configured and the hopping pattern follows a FH equation.

In [6], is is also propose to configure the start and end of the FH.

In [16], it is propose to allow FH to be configured commonly to multiple resource sharing the same pattern, for the purpose of overhead reduction.

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| **Company** | **Proposal** |
| [6] | Proposal 2: UL Tx frequency hopping pattern information should include the following SRS-Pos resource configuration information:   * In time domain:   + the start time of the frequency hopping pattern   + the end time of the frequency hopping pattern   + time gap between two consecutive hops (in unit of slot or OFDM symbol) * In frequency domain:   + partial overlapping size(granularity: PRB or RE)   + starting PRB index per frequency hopping   + the number of frequency hopping N, N={1,2,…,N\_max}   FFS:N\_max |
| [13] | Proposal 8: For RedCap UE with SRS, introduce partial overlapping in frequency for adjacent hops.   * The number of overlapping PRBs in adjacent hops is based on the bandwidth of each hop. |
| [21] | Proposal 2: For UE-assisted Redcap positioning, bandwidth overlap between the adjacent frequency hops should be supported.  Proposal 4: For RedCap positioning, the overlap of bandwidth between the adjacent hops is X PRB. The possible values of X are 1,2,4,8 PRB. |
| [22] | Proposal 3-4: For the configuration for SRS transmission frequency hopping, it is up to NW to determine whether there is partial overlapping in frequency domain, or the overlapping RB number between hops |
| [20] | Proposal 2: Following parameters should be included in SRS-pos frequency hopping configuration   * Number of hops, bandwidth of each hop, switching gap   Proposal 3: For configuration of frequency hopping for SRS-Pos, the followings can be considered:   * Alt. 1) based on the frequency hopping principles for SRS-MIMO resource configuration * Alt. 2) new frequency hopping configuration dedicated for the SRS-pos resource configuration   Proposal 6: For SRS for positioning frequency hopping configuration mechanism, following should be specified:   * Switching mechanism for SRS-pos frequency hopping configuration * Configuration of overlap size   Proposal 9: Support both of partially overlapped frequency hopping structure and non-overlapped one. |
| [17] | **Proposal 1: Support DL-PRS Rx frequency hopping and SRS for Positioning frequency hopping with overlapping tones.**   * **A UE cannot perform coherent DL-PRS processing or coherent SRS transmissions without overlapped hopping.**   **Proposal 3: Support in the specification multiple overlap options between 2 frequency-adjacent hops with a minimum value of 1 PRB.**    Proposal 7: Study further at least the following two options for the SRS frequency hopping pattern:   * Option 1: Use the current hopping formula of SRS as a starting point and update it such that there can be frequency domain overlap over 2 hops that are adjacent in frequency.   + Example of the update in the frequency-domain starting position :   Option 2: Use a staircase-like hopping formula with a parameter that controls the amount of overlap of frequency domain adjacent hops. |
| [1] | **Proposal 3: For RedCap UE Tx frequency hopping, RAN1 to discuss instantaneous SRS bandwidth configurations per hop.** |
| [3] | * ***For the sizes of overlapping bandwidth for different hops, the balance between phase error compensation performance and bandwidth span of frequency hopping should be considered.*** * ***A size smaller than 8 PRBs can be considered*** |
| [9] | Proposal 7: For the SRS frequency hopping, the SRS configuration independent with the existing UL BWP supports at least with the following configuration parameters   * Starting RB index and the number of RBs of the SRS resource, * Starting slot, the number of slots and/or the number of symbols * Periodicity and offset * SRS sequence ID * Number of frequency hops, * Gap time between frequency hops, * Number of RBs overlapped between frequency hops   Proposal 9: RAN1 should discuss the detailed feature to support frequency hopping while waiting for RAN4 input. |
| [7] | **Proposal 4**   * For SRS for positioning with frequency hopping for RedCap UEs, * Starting PRB, size of subband for each hop and switching period between adjacent hops are configured within an SRS resource. * Periodic, semi-persistent and aperiodic SRS transmission are supported. |
| [15] | ***Proposal 3: To support SRS for positioning frequency hopping, the hopping configuration need to identify the number of hops, the bandwidth of each hop, and the amount of overlap between hops. The hopping can be configured within an SRS resource or across resources. Both cases require an update to the existing configuration***. |
| [2] | ***Proposal 5: To achieve SRS Tx frequency hopping for RedCap UEs in RRC\_INACTIVE or RRC\_CONNECTED state, the configuration includes frequency location and bandwidth, SCS, and CP length for a larger BWP containing the frequency resources for all hops.***  ***Proposal 8: The enhancements of pos-SRS configuration should be supported to enable partial overlaps between hops for RedCap UEs.*** |
| [16] | * ***Proposal 9 SRS for positioning Tx bandwidth hopping is supported for RedCap UEs, by extending the SRS configuration with at least*** * ***i. The total BW to be covered over all hops*** * ***ii. The gap (in symbols) between two adjacent hops*** * ***iii. The overlap between two adjacent hops in frequency domain*** * ***1. FFS: whether the overlap is common for all hops or specific for each hop.*** * ***Proposal 10 A new repetition number can be introduced to indicate the number of SRS frequency hopping where each hop has one symbol in one SRS frequency hopping, or to indicate the number of symbols in one SRS hop, if partially overlapped SRS frequency hopping is configured.*** * ***Proposal 11 The frequency hopping configuration parameters can be configured both at resource set level and/or resource level. If frequency hopping is configured in both level for one or more of the FH parameters, the configured parameter(s) at the resource level overrides the resource set configuration for these parameters.*** |

### Round 1

Since there is a need to clarify how the hopping is configured first in section 4.1, the discussion on the issues of parameters may need to be delayed, hence it is seen as medium priority. The proposal below captures the majority view that a at least time between hops, hop bandwidth can be part of the configuration. Regarding configuring the overlap or the starting PRB for each hop, we need further discussion.

**Proposal 3.2a-1: for the support of Tx hopping, the configuration of SRS Tx positioning includes:**

* **The number of hops**
* **The hop bandwidth**
* **The time betwen hops**
* **FFS: overhead reduction for multiple SRS transmissions with the same parameters.**

**Proposal 3.2b-1 For the overlap configuration of SRS Tx hopping:**

* + **Alt1: include the starting PRB for each hop**
  + **Alt2: include the starting PRB for the first hop and a parameter for the configured overlap**

Comments can be entered in the table below:

**Proposal 3.2a-1:**

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| **Company** | **comment** |
| vivo | This proposal depends on the discussion of Proposal 4.1.2. If hopping is configured across SRS resources, different parameters may be configured.  So, we prefer to modify the main bullet as follows  **Proposal 3.2a-1: for the support of Tx hopping, the configuration of SRS Tx positioning may include~~s~~ one or more parameter as following:**   * **Hop ID** * **The number of hops** * **The hop bandwidth** * **The time between hops** * **FFS: overhead reduction for multiple SRS transmissions with the same parameters.** |
| Huawei, HiSilicon | Support. |
| NEC | Support in general. We think overlap should be included as one of the parameters too. |
| ZTE | Ok in general. |
| CMCC | It should wait for the progress on Proposal 3.1-1 |
| Intel | We are fine with the proposal. |
| Apple | Fine with proposal |

**Proposal 3.2b-1:**

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| **Company** | **comment** |
| vivo | This proposal depends on the discussion of Proposal 4.1.2. So, we prefer to more general option for SRS Tx hopping. In addition, the starting PRB may be configured for first hop by the frequency location of virtual BWP, or Nshift in SRS for MIMO  **Proposal 3.2b-1 For the overlap configuration of SRS Tx hopping, it may include one or both options as following:**   * + **The starting PRB for hop(s)**     - **FFS: first hop or each hop**   + **The overlap bandwidth**   **Note: This doesn’t mean the new parameter will be introduced** |
| Huawei, HiSilicon | Alt.2 |
| NEC | Support. And we prefer the Alt2 slightly. |
| ZTE | Alt. 1. |
| mtk | We slightly prefer Alt.1, because it could control the hopping being ascending or descending |
| Intel | We slightly prefer Alt. 2 |
| Apple | Alt 2 |

## Collision rules [MEDIUM]

### Background

In [6,9,20,22] Collision with other UL transmission are discussed and propose to introduce a window where UL SRS with FH is transmitted without being interruption from other UL signals, similar to DL measurement gaps. This is essentially a special case of collision rules, where the UL SRS with FH always have highest priority.

[5,7,21,22], propose to re-use or extend collision rules and priorities from the existing dropping rules.

[17,22] mentions that the collision rules should include the retuning time.

[3,16] propose to introduce additional rules for dropping of one or more hops based on the collision of the SRS with FH with other signals only in some of the hops.

[16] proposes to define collision rules when one or more hop is within the active BWP, and consider SRS to be high priority outside of the active BWP.

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| **Company** | **Proposal** |
| [14] | Proposal 5: Study scenarios of collision between SRSp and UL channels and prioritization of SRSp during SRSp hopping |
| [6] | Proposal 4: It is necessary to introduce a window so that the RedCap UEs can continuously transmit SRS-Pos signals with UL frequency hopping multiple times without being interrupted by PUSCH/PUCCH. |
| [21] | Proposal 7: A mechanism should be supported to avoid the collision of a high-priority signal with the UL SRS transmission and DL PRS reception for positioning purposes in the FDD mode. |
| [22] | Proposal 3-2: For the configuration for SRS transmission frequency hopping, consider to have the transition time at the end to retune back to the original BWP  Proposal 3-3: For the configuration for SRS transmission frequency hopping, consider to have the transition time at the beginning if the first transmission is not exactly within the uplink BWP    Proposal 3-5: For SRS transmission frequency hopping, UE is not expected to transmit data or other reference signals  Proposal 3-6: For SRS transmission frequency hopping, consider a mechanism to abort the transmission in an instance when other uplink transmission has higher priority |
| [20] | Proposal 8: Consider following for handling of collision between frequency hopping SRS transmission and other UL transmission   * Opt. 1) UL time domain window where UE is expected to transmit only SRS for positioning * Opt. 2) Priority rule between SRS for positioning and other UL transmission |
| [17] | **Proposal 6: For SRS for Positioning frequency hopping:**   * **Define SRS for positioning associated with a CC (and not an active BWP) with each own numerology and bandwidth (e.g. similar to the SRS for Positioning of Rel-17 RRC inactive feature).** * **Introduce a transmission/switching/retune gap before and after a transmission of such an SRS resource.** |
| [3] | Proposal 8:  • For SRS for positioning frequency hopping collides with other DL/UL reception/transmission, the following aspects should be considered.  - The dropping rules should include at least one of the following   Alt 1: UE drops all the SRS hops   Alt 2: UE drops affected hops   Alt 3: UE drops affected symbols  - The other DL/UL reception/transmission should include other UL signals/channels, DL signals/channels in TDD, DL signals/channels for half-duplex UE (HD-UE) in FDD |
| [5] | ***Proposal 6: Define scheduling restriction rules for SRS frequency hopping transmission should be supported.*** |
| [9] | **Proposal 8:** Support an UL time window where the UE is not expected to receive/transmit other signals/channels and is only expecting to transmit FH SRS for positioning. |
| [7] | **Proposal 5**   * Switching period associated with reception of DL PRS and transmission of SRS for positioning with frequency hopping has same priority as the corresponding DL PRS and SRS for positioning. |
| [16] | **Proposal 6 When the SRS for positioning is using Tx bandwidth hopping, the active BWP bandwidth does not apply during transmission of the hops outside of the BWP.**  **Proposal 7 The UE is not expected to transmit other UL signals in the same slot as the one used by a SRS with Tx bandwidth hopping while the UE is hopping outside of the active BWP bandwidth.**   * **FFS: collision rules to prioritize SRS or other transmissions.**   ***Proposal 13 If the SRS for positioning with BW hopping collides with a high priority PUSCH/PUCCH, the colliding slot(s) and the remaining SRS slot(s) in the hopping sequence are dropped.*** |

### Round 1

We can start the discussion by discussing whether a UL window, or collision rules, or both, should be supported.

**Proposal 3.3-1: For RedCap UEs positioning transmitting the UL SRS with frequency hopping, regarding the collisions between other UL sigals and the UL SRS with frequency hopping support one or more of the following, according to UE capabilities:**

* **Support an UL time window where the UE is not expected to receive/transmit other signals/channels and is only expecting to transmit FH SRS for positioning.**
* **Support collision rules between the UL SRS with frequency hopping and other UL transmissions**
  + **FFS: details on the collision rules, including only dropping the UL SRSs in colliding hops.**

Comments can be entered in the table below:

**Proposal 3.3-1:**

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| --- | --- |
| **Company** | **comment** |
| InterDigital | Our suggestion is to change the proposal to the study since we need to understand the details for each option.  **Proposal 3.3-1: For RedCap UEs positioning transmitting the UL SRS with frequency hopping, regarding the collisions between other UL sigals and the UL SRS with frequency hopping ~~support~~ ~~one or more of~~ study whether to support one or both of the following options, according to UE capabilities:**   * **Option 1 : ~~Support an~~ UL time window where the UE is not expected to receive/transmit other signals/channels and is only expecting to transmit FH SRS for positioning.**   + **FFS details of an UL time window** * **Option 2 : ~~Support~~ collision rules between the UL SRS with frequency hopping and other UL transmissions**   + **FFS: details on the collision rules~~, including only dropping the UL SRSs in colliding hops.~~** |

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| Huawei, HiSilicon | We do not support the window. It should be up to network configuration following the existing priority rule between SRS and other signals/channels. |
| ZTE | We prefer to delete the first bullet, in our understanding the first bullet is a special case of the second bullet.  **Proposal 3.3-1: For RedCap UEs positioning transmitting the UL SRS with frequency hopping, regarding the collisions between other UL sigals and the UL SRS with frequency hopping support ~~one or more of~~ the following, according to UE capabilities:**   * **~~Support an UL time window where the UE is not expected to receive/transmit other signals/channels and is only expecting to transmit FH SRS for positioning.~~** * **Support collision rules between the UL SRS with frequency hopping and other UL transmissions**   + **FFS: details on the collision rules, including only dropping the UL SRSs in colliding hops.**   + **FFS: Support an UL time window where the UE is not expected to receive/transmit other signals/channels and is only expecting to transmit FH SRS for positioning.** |
| CMCC | We are supportive to discuss the collision rules, but we prefer to change “support” to “study” at this stage.  For the 1st bullet: Note that in R16/17 positioning, the priority of SRS is lower than other UL signals/channels and no optimization on the prioritization has been supported. From this perspective, we don’t see strong need to prioritize SRS frequency hopping for RedCap UE by defining a time window.  For the 2nd bullet: We are open to discuss a collision rule/timeline, and we think that a similar mechanism of the collision timeline for UE processing DL PRS within a PPW can be considered as a starting point. |

## Support of aperiodic PRS / SRS [paused]

### Background

Two companies propose to consider how to handle aperiodic transmission of the SRS for positioning with respect to frequency hopping.

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| **Company** | **Proposal** |
| [20] | Proposal 7: Support frequency hopping of SRS-pos is activated/deactivated by MAC-CE or DCI. |
| [9] | Proposal 10: RAN1 should discuss the way to reduce the time gap and unnecessary signalling overhead of RedCap FH for positioning (e.g., support a single DCI triggering all the switching). |

### Round 1

From the FL perspective, it is preferable to treat the issue once the design of the SRS configuration for frequency hopping has progressed further. If a MAC CE is preferred to trigger the SRS with frequency hopping, RAN2 should be consulted on the feasibility. The discussion on the issue is thus paused until progress is made on the SRS configuration.

Comments can be entered in the table below:

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| --- | --- |
| **Company** | **comment** |
|  |  |

## Power control [LOW]

### Background

In [21] power control for the SRS while hopping is discussed, and it is proposed to use the same pathloss estimate across the hopping procedure.

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| **Company** | **Proposal** |
| [16] | Proposal 12 UE uses same pathloss estimation for SRS transmission during one SRS frequency hopping duration if uplink power control is configured. |

### Round 1

As only a single company has discussed the issue, we can start by collecting views.

**Proposal 3.5-1: UE uses same pathloss estimation for SRS transmission during one SRS frequency hopping duration if uplink power control is configured.**

Comments can be entered in the table below:

**Proposal 3.5-1:**

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| --- | --- |
| **Company** | **comment** |
|  |  |

# Conclusion

TBD

# References

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