**3GPP TSG RAN WG1 #105e R1-210zzzz**

**e-Meeting, May 10th – 27th, 2021**

**Source: Moderator (Intel Corporation)**

**Title: Feature Lead Summary #0 for Enhancements of UL-AOA Positioning**

**Agenda item:** **8.5.2**

**Document for:**  **Discussion and Decision**

# Introduction

In this contribution, we provide summary of the enhancements for UL-AOA positioning proposed by companies in contributions [1]-[18]. In addition, we provided overview of contributions [19]-[34] on NR-Positioning in RRC\_INACTIVE state and on-demand DL PRS support. In addition, we formulate tentative proposals for RAN WG1 discussion and decision for above topics.

# Proposed Priority of Discussion

## Round #1

In this section, for each topic we provide guidance in terms of priority of discussion in the first round. It is proposed to focus on discussion for the following design aspects:

* UL-AOA Enhancements - Section 3
* Aspect #1: Coordinate System for UL-AOA Assistance
* Aspect #2: UL-AOA Assistance for NR Positioning Methods
* Aspect #3: Granularity of UL-AOA Assistance
* Aspect #5: UL-AOA Assistance Signalling Details
* Aspect #6: UL-AOA Report per SRS for Positioning Resource / Resource Set
* NR Positioning in RRC\_INACTIVE State - Section 4
* Aspect #1: Transmission of SRS for positioning
* Aspect #2: Configuration of SRS for positioning
* Aspect #7: Support of DL positioning in RRC\_INACTIVE state
* On-demand DL PRS - Section 5
* Aspect #1: On-demand PRS support
* Aspect #2: DL PRS parameters for on-demand UE / LMF initiated request

UL-AOA Enhancements

## Aspect #1: Coordinate System for UL-AOA Assistance

The following agreement was made with respect to enhancements of UL-AOA expected value and uncertainty range reporting.

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| * Select one of the following coordinate system alternatives for signaling UL AoA/ZoA assistance information   + Alt.1: Only GCS is supported for AoA/ZoA assistance information indication   + Alt.2: Both GCS and LCS are supported for AoA/ZoA assistance information indication |

Based on review of contributions, the following views were expressed:

* Alt.1: Only GCS is supported for AoA/ZoA assistance information indication
  + Preferred by 7 companies: [Huawei, [1]], [ZTE, [4]], [CMCC, [5]], [InterDigital, [8]], [NTT DOCOMO, [16]], [Ericsson, [18]], [Samsung, [12]]
* Alt.2:
  + Preferred by 7 companies: [vivo, [2]] (If the reference angle is defined in LCS, support gNB to provide LCS to GCS translation information to LMF in TRP Information), [CATT, [3]] (for a gNB/TRP with a linear antenna array, the expected azimuth angle of arrival needs to be provided in LCS), [Qualcomm, [6]], [OPPO, [7]], [Intel, [9]], [LGE, [13]], [Nokia, [14]]

Considering that Alt.2 is more general and universal one, it is recommended to take this option.

### Round #1

**Proposal 3.1-1**

* Both GCS and LCS are supported for UL AoA/ZoA assistance information indication

Companies are invited to provide comments on above proposal and reasons to not both coordinate systems, if any

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| --- | --- |
| Company Name | Comments |
| CATT | Our preference is to support both to give the freedom for the LMF to provide the information especially for TRP linear antenna array. In case LMF cannot provide the information in TRP LCS, the LMF may also send the information in GCS. |
| Qualcomm | Support |
| Nokia/NSB | Support Alt.2 |
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## Aspect #2: UL-AOA Assistance for NR Positioning Methods

The applicability of UL-AOA assistance information to other NR positioning methods was discussed at the previous meeting:

* Signaling of AoA/ZoA assistance information (expected value and uncertainty range) is supported for UL-TDOA and Multi-RTT positioning methods

Based on review of contributions the following views were expressed:

* Support: [Huawei, [1]], [ZTE, [4]], [InterDigital, [8]], [Nokia, [14]], [NTT DOCOMO, [16]]
* Do not support: [OPPO, [7]], [Apple, [10]]
* Clarification needed: [vivo, [2]] (beam selection, LOS/NLOS identification)
* Not necessary: [CMCC, [5]] (applicable if hybrid UL-AOA + UL-TDOA/Multi-RTT are used)

According to FL understanding the use of assistance information will not be specified and it is up to gNB how to use it. Majority of companies that expressed views support signaling of UL-AOA assistance information for UL-TDOA/Multi-RTT.

### Round #1

**Proposal 3.2-1**

* LMF to gNB signaling of UL AoA/ZoA assistance information (expected value and uncertainty range) is supported for UL-TDOA and Multi-RTT positioning methods

Companies are invited to provide comments on above proposal

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| Company Name | Comments |
| CATT | Our preference is to support it. A gNB with advanced algorithm ma use the information for more reliable UL-TDOA and Multi-RTT measurements. |
| Qualcomm | Support |
| Nokia/NSB | Support FL’s proposal. In addition to UL-AoA technique, the assistance information is useful for UL-TDOA and Multi-RTT to determine spatial beam for TRP/RP. |
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## Aspect #3: Granularity of UL-AOA Assistance

In [Qualcomm, [6]] it is proposed to support a granularity of 0.1 degrees for the expected AoA (φAOA) , expected ZoA (θAOA ) and the corresponding uncertainties. Considering that this is one of the remaining opens for UL AOA/ZOA discussion it makes sense to finalize this topic and provide input to RAN3.

### Round #1

To finalize discussion on, the granularity / value ranges for UL-AOA/ZOA assistance information need to be agreed.

**Proposal 3.3-1**

* Define granularity and value ranges for expected UL-AOA/ZOA and uncertainty
  + Granularity of 0.1 degrees is applied for the expected AoA (φAOA) , expected ZoA (θAOA ) and the corresponding uncertainty values

Companies are invited to provide comments on above proposal

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| --- | --- |
| Company Name | Comments |
|  | Granularity of AOA/ZOA  Value range of AOA/ZOA |
| CATT | No strong view. We don’t see the need to have 0.1 degree granularity in the expected AoA/ZoA. In general LMF may only provide rough information of the expected AoA/ZoA. |
| Qualcomm | Support |
| Nokia/NSB | We are OK. |
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## Aspect #4: Additional UL-AOA Assistance Signalling

At the previous meeting it was also agreed to study additional signaling is needed for UL AOA assistance information

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| * FFS: Additional signaling for AoA/ZoA assistance information (expected value and uncertainty range) |

The following views were expressed:

* Support:
  + [Fraunhofer, [17]] (DL-PRS resource for the expected AoA/ZoA and uncertainty range)
* Do not support:
  + [vivo, [2]] (not needed), [CMCC, [5]]

### Round #1

Considering limited discussion in contributions and expressed views that there is no need for additional signaling, it seems there is no strong motivation and consensus to define additional signaling for UL AoA/ZoA assistance information

**Proposal 3.4-1**

* No consensus to define additional signaling for UL AoA/ZoA assistance information

Companies are invited to provide comments on above conclusion

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| Company Name | Comments |
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## Aspect #5: UL-AOA Assistance Signalling Details

In [Ericsson,[18]], the following is proposed with respect to UL-AOA assistance information signaling:

* The gNB can signal that it requires an expected AoA/ZoA and uncertainty window
* The gNB can be (optionally) provided with the expected AoA/ZoA and uncertainty window during initial LMF measurement request message, as part of the SRS configuration. The LMF can also provide (optional) updates on the expected AoA/ZoA and uncertainty window as part of the measurement update message. RAN3 can discuss the details of the request procedure.
* In the signalling of the AoA/ZoA uncertainty, the uncertainty ranges ΔφAOA and ΔθAOA are optionally present
* In the signalling of the expected AoA/ZoA the expected φAOA is optionally present and θAOA is always present.
* The gNB can provide an update to the uncertainty window as part of the measurement report.
  + FFS: details on the update (e.g. window used by the gnodeB, indicator that the window was used).
* Send an LS to RAN3 reflecting the NRPPa impact

### Round #1

Based on review of contributions it seems the situation has not changed comparing to the last meeting and majority of companies (except one) assume that further discussion on signaling details of UL-AOA/ZOA assistance information can be directly handled by RAN3.

**Proposal 3.5-1**

* Send an LS to RAN3 (cc to RAN2) capturing RAN1 agreements on UL AOA/ZOA assistance information and request them to define signaling

Companies are invited to provide views on above proposal

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| --- | --- |
| Company Name | Comments |
| CATT | Support. Maybe with other agreements to be made in this meeting. |
| Qualcomm | Support |
| Nokia/NSB | Support. Send an LS including further agreement or conclusion of the ongoing discussion. |
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## Aspect #6: UL-AOA Report per SRS for Positioning Resource / Resource Set

In [Intel,[9]] it is proposed to consider the following options for the UL-AOA measurement report:

* Option 1: UL-AOA reporting per SRS for positioning resource
* Option 2: UL-AOA reporting per SRS for positioning resource set

### Round #1

Companies are invited to provide views on the options for UL-AOA measurement report supported by gNB:

**Proposal 3.6-1**

* For UL-AOA reporting select among the following options
  + Option 1: UL-AOA reporting per SRS for positioning resource
  + Option 2: UL-AOA reporting per SRS for positioning resource set

Companies are invited to provide comments on above options

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| Company Name | Comments |
| CATT | Support Option 1. For Option 2, it is unclear how the information is useful for LMF in calculating UE position. |
| Nokia/NSB | Support Option 1. The measurement can be different depending on the beam direction. |
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## Aspect #7: Additional Paths and Multiple UL-AoAs

The following aspects were identified with respect to support of multiple UL-AOA measurements in contributions:

* Support multiple UL-AOA measurements per additional path.
  + [Huawei, [1]]
* Specify the total number of reported UL-AOAs for the first arrival path corresponding to the same timestamp
  + [Intel, [9]]
* Number of UL-AOA measurements per additional path *N*.
  + Different views were expressed by companies:
    - *N* = 1
      * [CATT,[3]], [Nokia,[14]]
    - *N* ≥ 1
      * [Huawei,[1]] (same as for the FAP, max number is signaled by LMF)

### Round #1

Enhancements for additional paths are better to discuss in NLOS/multipath mitigation AI - 8.5.5. In this agenda item it is proposed to finalize UL-AOA measurements for the first arrival path.

The following set of proposals is recommended to discuss in NLOS/multipath mitigation - AI

* UL-AOA measurements per additional paths are supported
* Select one option for reporting to LMF multiple UL-AOA values per additional path
  + Option 1: NR supports reporting to LMF of *N* = 1 UL-AOA measurement values per additional path for the same timestamp
  + Option 2: NR supports reporting to LMF of N ≥ 1 UL-AOA measurement values per additional path for the same timestamp
    - *N* indicates a maximum value provided by LMF
    - Note:
      * It is up to gNB whether to report *N* UL-AOA values for each additional path

**Proposal 3.7-1**

* LMF indicates maximum number of reported UL-AOAs values for the first arrival path corresponding to the same timestamp from the set {1, 2, 4, 6, 8}

Companies are invited to provide comments on above proposal

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| Company Name | Comments |
| CATT | Prefer deleting [6, 8]. It may not be useful to reporting many UL-AOAs from the same path. |
| Qualcomm | We want to have at least 8 as an option, and FFS for more. |
| Nokia/NSB | Similar view with CATT. We prefer to remove [6, 8] as the use case is not clear. |
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## Aspect #8: Reference UE for gNB/TRP Antenna Array Calibration

The possibility to use reference UE to facilitate precise UL-AOA measurements and positioning was discussed:

* LMF sends the expected angle of the reference device to gNB for TRP antenna-element wise calibration.
  + [Huawei, [1]]

### Round #1

The concept of reference UE needs to be agreed first (i.e. before treating this proposal). May be, it is better to discuss all aspects related to reference UE in a single AI 8.5.1.

**Proposal 3.8-1**

* LMF sends the expected angle of the reference device to gNB for TRP antenna-element wise calibration.

Companies are invited to provide comments on above proposal

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| --- | --- |
| Company Name | Comments |
| CATT | Support |
| Qualcomm | Reference Devices need to be agreed first |
| Nokia/NSB | We first need to discuss whether or not to support reference device. |
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## Aspect #9: UL-AOA Report Enhancements

The following aspects were discussed with respect to UL-AOA measurements and reporting enhancements:

* Identification of SRS resource and report of SRS resource ID with UL-AOA measurements [vivo, [2]], [Sony,[11]] (with RSRP), [OPPO, [7]]
* Support of UL-AOA, SRS-RSRP and UL RTOA measurements for the first arrival path [OPPO, [7]]
* Support of UL-AOA, SRS-RSRP and UL RTOA measurements for additional paths [OPPO, [7]], [Qualcomm, [11]] (RSRP, RTOA/ gNB Rx-Tx, AOA tuple in single report)
* Support UL-SRS-RSRP measurement within a configured time window or for the first arrival path only that is measured within a configured time window [Apple, [10]]
* Support gNB reporting of statistical property (standard deviation) for UL-AOA measurements [Sony, [11]]

### Round #1

**Proposal 3.9-1**

* For UL-AOA positioning, select alternative for NR support of path-specific RSRP measurements based on SRS (for positioning, MIMO)
  + Alt.1: NR supports reporting of path specific RSRP measurements for the first arrival path only
  + Alt.2: NR supports reporting of path specific RSRP measurements for the first arrival path and for additional paths
  + Alt.3: NR supports reporting of RSRP measurements in a pre-configured time window
    - Power of paths outside of the window is excluded. FFS details of time window configuration
  + FFS definition of path specific RSRP measurements and whether it is supported per SRS resource or SRS resource set (for positioning, MIMO)
* For UL-AOA positioning, select alternative for support of path-specific UL-RTOA measurements based on SRS (for positioning, MIMO)
  + Alt.1: NR supports reporting of path specific UL-RTOA measurements for the first arrival path only
    - Note: UL-RTOA for the first arrival path is supported for UL-TDOA (it is discussed in the context of UL-AOA)
  + Alt.2: NR supports reporting of path specific UL-RTOA measurements for the first arrival path and for additional paths
  + FFS definition of path specific RTOA measurement and whether it is supported per SRS resource or SRS resource set (for positioning, MIMO)

Companies are invited to provide comments on initial proposal:

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| Company Name | Comments |
| CATT | So far, we don’t have the definition of path-specific RSRP. |
| Qualcomm | Alt. 2 & 3 are not really mutual exclusive. The LMF may request paths that are not further away than X nsec from the earliest path and the gNB reports accordingly. However, this is an optimization over the main feature of reporting additional paths. Preference for supporting at least Alt. 2.  Not sure why we have to separate RSRP and RTOA/Rx-Tx. The gNB measures an SRS resources, derives the angle/Time channel response, and reports back the (Timing Measurements, relative RSRP, AoA) for multiple paths and angles.  To CATT: we could try to define the per path RSRP. We consider these as can be solved later. |
| Nokia/NSB | We prefer to have separate discussions on two main bullets. In case of the first bullet, before discussing reporting options, we first need to discuss whether or not to define path-specific RSRP. |
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## Aspect #10: Antenna Reference Points

In [ZTE, [4]], it is mentioned that at least in the following cases, current specification doesn’t support gNB/TRP to report ARP information of UL measurement results:

* Measurement Beam Information is not requested by LMF. However, the gNB/TRP still expects to report measurement results from multiple ARPs.
* The gNB/TRP only supports UL based positioning, so that there is no DL PRS resources configured.
* The gNB/TRP is a reception point (RP) attached with multiple ARPs, where the RP only supports UL reception.

It is proposed that Rel-17 should be able to report UL-AOA measurement results being associated with ARP information (e.g. ARP ID and corresponding geographical coordinate). In addition, it is proposed to further study whether above enhancement can be also applicable to UL-TDOA and Multi-RTT.

### Round #1

To facilitate further discussion/decision by the group, companies are invited to provide views/feedback on association of UL measurements with ARP ID / corresponding geographical coordinate.

Companies are invited to provide comments on this aspect in table below:

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| Company Name | Comments |
| CATT | RAN4 may need to be consulted on whether gNB is able to provide beam-specific ARP. |
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## Aspect #11: UE TX Beam Refinement

In [LGE, [13]], it is proposed to provide additional information for UE TX beam refinement, either:

* Location of both TRPs and UE
* TRP ID and UE location

### Round #1

In general, UE TX beam alignment can be supported through spatial relationship of SRS for positioning resource. The need for additional information was not discussed so far.

Companies are invited to provide views on LMF signalling to facilitate UE TX beam alignment: 1) location of both TRPs and UE or 2) TRP ID and UE location

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| Company Name | Comments |
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## Aspect #12: Beamforming and UL AOA Estimation

In [Nokia, [14]], it is proposed to study beam interpolation based AoA estimation method based on UL-RSRP measurements (accurate and effective AoA measurement methods based on UL-RSRP).

In [Samsung, [12]], it is proposed to support differential beamforming technique for UL-AOA positioning methods.

### Round #1

To facilitate further discussion/decision by the group, companies are invited to provide views/feedback on beam interpolation based AoA estimation and differential beamforming.

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| Company Name | Comments |
| Nokia/NSB | Study beam interpolation based AoA estimation method based on UL-RSRP measurements for the purpose of performance improvement, and identify the potential spec impact. |
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## Aspect #13: Velocity for UL-AOA Measurements

In [Ericsson, [18]], it is proposed that for estimating AoA at TRPs, velocity of the UE should be reported to the network.

### Round #1

Companies are invited to express views on above aspect:

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| --- | --- |
| Company Name | Comments |
| Nokia/NSB | It may be related to RAT-independent technique. We are not sure if it could be discussed in RAN1. |
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## Aspect #14: SRS for Positioning Power Control

In [Samsung, [12]], it is proposed to consider power control enhancement for SRS-pos to improve UL-AOA based solution. It needs to be clarified which enhancement is considered by proponent.

### Round #1

Companies are invited to provide views on SRS power control enhancements for UL-AOA solution:

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| --- | --- |
| Company Name | Comments |
| CATT | Maybe not in the WI scope. |
| Qualcomm | Not within scope |
| Nokia/NSB | Even if the power control is not explicitly described in the WID, it is highly related to the performance improvement of AoA positioning. We are supportive of enhancements on the open-loop power control for effectively transmitting SRS to neighbour cells |
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NR Positioning in RRC\_INACTIVE State

The following list of design aspects / enhancements was identified based on submitted contributions for NR positioning support by RRC\_INACTIVE UEs

## Aspect #1: Transmission of SRS for positioning

The support of SRS for positioning transmission by RRC\_INACTIVE UEs is discussed by majority of companies that have submitted contributions: vivo, CATT, CMCC, Qualcomm, InterDigital, Intel, Samsung, LGE, Huawei, Xiaomi. The following views were expressed:

* [Qualcomm, [23]]: Enable transmitting SRS for Positioning during RRC Inactive State
* [vivo, [19]]: Support of SRS for positioning in RRC\_INACTIVE state
* [CMCC, [22]]: Support configuration and transmission of UL SRS for positioning in RRC\_INACTIVE state.
* [Intel, [27]]: For support of UL and DL + UL positioning by RRC\_INACTIVE UEs, RAN1 to discuss support of SRS for positioning transmission in RRC\_INACTIVE state
* [LGE, [29]]: If UL positioning measurement is supported for UE in RRC inactive state, RAN1 needs to consider how to provide UEs with SRS configuration in RRC inactive state.
* [Xiaomi, [32]]: SRS transmission for inactive UE can be triggered by gNB through paging.

### Round #1

Considering that majority of submitted contributions suggest defining support for transmission of SRS for positioning, the following is proposed:

**Proposal 4.1-1**

* + SRS for positioning transmission is supported by UEs in RRC\_INACTIVE state for UL and DL+UL positioning

Companies are invited to provide views on proposal:

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| --- | --- |
| Company Name | Comments |
| CATT | Support |
| vivo | Support |
| Qualcomm | Support |
| Nokia/NSB | In our view, SRS transmission for RRC\_Inactive state is a low priority issue. It should not be discussed until progress on DL is made. |
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## Aspect #2: Configuration of SRS for positioning

Companies supporting SRS for positioning transmission by RRC\_INCATIVE UEs have also discussed potential options for SRS for positioning configuration. The following views were expressed:

* [Qualcomm, [23]]: Provide the SRS-SDT configuration in the RRC Release message
* [vivo, [19]]:
* Transmit SRS configuration via RRC release when UE is in connected state for UL positioning in inactive states
* Validity criteria for SRS configuration and fallback (perform UL or update SRS configuration)
* [LGE, [29]]: If UL positioning measurement is supported for UE in RRC inactive state, RAN1 needs to consider how to provide UEs with SRS configuration in RRC inactive state.
* [CATT, [20]]: Support the following three SRS configuration methods for UL positioning in RRC\_INACTIVE state:
* UE keeps the SRS-Pos configuration information obtained in RRC\_CONNECTED state.
* gNB sends SRS-Pos configuration information to UE through the paging message.
* Introducing a new RACH procedure for UE to obtain the SRS-Pos configuration information.
* [InterDigital, [25]]: Support the use of pre-configured SRSp configuration received by UE during RRC CONNECTED for SRSp transmission when in RRC INACTIVE

### Round #1

Views on SRS for positioning configuration for RRC\_INCATIVE UEs are somewhat diverse. This design aspect may also need RAN2 considerations. Given that it is the first time when this aspect is discussed in RAN1 it seems more discussion may be needed including RAN2 feedback/decision.

**Proposal 4.2-1**

* + Further study details of SRS for positioning configuration for RRC\_INACTIVE UEs and decide on design option(s) to be supported by specification:
    - Option 1: SRS for positioning configuration is provided in the RRC Release message
    - Option 2: SRS for positioning configuration is pre-configured
    - Option 3: UE keeps the SRS-Pos configuration information obtained in RRC\_CONNECTED state
    - Option 4: gNB sends SRS-Pos configuration information to UE through the paging message
    - Option 5: Introduce a new RACH procedure for UE to obtain the SRS-Pos configuration information
    - Other options are not precluded
  + Send LS to RAN2 with the list of options identified and discussed by RAN1 for configuration of SRS for positioning to RRC\_INACTIVE UEs and ask for input and feedback

Companies are invited to provide views on above proposal:

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| --- | --- |
| Company Name | Comments |
| CATT | Support |
| vivo | Support the first bullet.  On the proposal (2nd bullet) to send LS to RAN2 on the list of options, we feel a bit too early to send LS to RAN2 on this matter right now. Given the first bullet says to further study and decide in RAN1 on the options, we think an LS may be more appropriate when RAN1 actually have discussed and made some progress/agreement on these options later. |
| Qualcomm | Support the first bullet. No need for an LS now. |
| Nokia/NSB | In our view, SRS transmission for RRC\_Inactive state is a low priority issue. It should not be discussed until progress on DL is made. |
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## Aspect #3: Triggering of SRS for positioning transmission by UEs in RRC\_INACTIVE state

The following views were expressed for

* [InterDigital, [25]]: Support transmission of SRSp configuration (e.g. using SDT) or indication for initiating SRSp transmission to UE when in INACTIVE
* [Xiaomi, [32]]: SRS transmission for inactive UE can be triggered by gNB through paging.

### Round #1

Mechanisms and conditions to trigger SRS for positioning transmissions by RRC\_INACTIVE UEs need to be further discussed by RAN1.

**Proposal 4.3-1**

* + Further study conditions and signaling details to trigger SRS for positioning transmissions by RRC\_INACTIVE UEs

Companies are invited to provide views on proposal:

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| --- | --- |
| Company Name | Comments |
| Qualcomm | To generic at this stage |
| Nokia/NSB | In our view, SRS transmission for RRC\_Inactive state is a low priority issue. It should not be discussed until progress on DL is made. |
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## Aspect #4: TA for SRS for positioning

The following views were expressed by selected companies regarding TA for SRS for positioning transmission by RRC\_INACTIVE UEs:

* [Huawei, [31]]: At least support the following TA maintenance for SRS transmission in RRC\_INACTIVE reused from SDT.
* The TA value can be either the one in RRC\_CONNECTED or provided in RRC Release
* The TA timer for SRS transmission is provided in RRC Release
* The TA validation is based on RSRP
* [Qualcomm, [23]]: TA validation procedures applicable to CG-SDT to also be applicable to SRS-SDT

**FL Response**

* TA design details can be discussed at a later stage assuming that transmission of SRS for positioning by RRC\_INACTIVE UEs is agreed.

Companies are invited to provide views on FL response:

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| --- | --- |
| Company Name | Comments |
| Qualcomm | OK |
| Nokia/NSB | In our view, SRS transmission for RRC\_Inactive state is a low priority issue. It should not be discussed until progress on DL is made. |
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## Aspect #5: OLPC for SRS for positioning

The following views were expressed by selected companies regarding OLPC for SRS for positioning transmission by RRC\_INACTIVE UEs:

* [Huawei, [31]]: At least support the following power control mechanism for SRS transmission in RRC\_INACTIVE based on Rel-16 feature.
* Open loop power control based on
* Reference signal from the serving cell
* Reference signal from the non-serving cell if the RRM requirement for RRC\_INACTIVE state can be reused
* [Qualcomm, [23]]: SRS-SDT configuration may contain path loss references and spatial relation references for the purpose of open loop power control and Tx beam determination of the SRS-SDT during the RRC Inactive state

**FL Response**

* OLPC design details can be discussed at a later stage assuming that transmission of SRS for positioning by RRC\_INACTIVE UEs is agreed.

Companies are invited to provide views on FL response:

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| --- | --- |
| Company Name | Comments |
| Qualcomm | OK |
| Nokia/NSB | In our view, SRS transmission for RRC\_Inactive state is a low priority issue. It should not be discussed until progress on DL is made. |
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## Aspect #6: RACH for NR positioning in RRC\_INACTIVE state

The following views were expressed by selected companies regarding use of RACH procedure for NR positioning transmission by RRC\_INACTIVE UEs:

* [CMCC, [22]]: Support using RACH preamble as the UL reference signals for RRC\_inactive state positioning
* Support enhancing NR E-CID using RACH preamble to obtain the UL measurements.
* [Xiaomi, [32]]:
* Random access preamble can be reused as UL reference signal for Inactive UE.
* Random access procedure can be reused for UL and DL&UL positioning of Inactive UE.
* [LGE, [29]]: gNB 🡪 UE: PRS and measurement report / gap configuration, LCS request
* Msg 2 and/or Msg4 (in four-step RACH), msgB (in two-step RACH)
* Paging (DCI and/or PDSCH)
* WUS (if signalling is needed for simple purpose such as triggering of positioning measurement)
* [LGE, [29]]: UE 🡪 gNB: measurement gap request, measurement report
* Msg1 and/or Msg3 (in four-step RACH), msgA (in two-step RACH)

**FL Response**

* The above aspects can be discussed at a later stage assuming that transmission of SRS for positioning by RRC\_INACTIVE UEs is agreed.

Companies are invited to provide views on FL response:

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| Company Name | Comments |
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## Aspect #7: Support of DL positioning in RRC\_INACTIVE state

The following views were expressed by selected companies regarding support of NR DL Positioning by RRC\_INACTIVE UEs:

* [Intel, [27]]: For support of DL positioning by RRC\_INACTIVE UEs, measurement and reporting enhancements are decided directly by RAN2
* [CATT, [20]]: For UE-assisted DL positioning for UEs in RRC\_INACTIVE state, support: a) broadcasting DL PRS assistance information in the system information; b) UE reporting measurement results to the serving gNB using RACH, and c) serving gNB forwarding the DL measurement results to LMF.
* [Nokia, [30]]: Make at least the DL RSTD and DL PRS-RSRP measurements applicable for the RRC\_INACTIVE state.

**FL Response**

* Support of DL measurements by RRC\_INACTIVE UEs and report can be directly discussed in RAN2

Companies are invited to provide views on FL response:

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| --- | --- |
| Company Name | Comments |
| CATT | We are trying to understand the intention of the proposal. In the WID, it is clear the WI includes “Support of UE positioning measurements for UEs in RRC\_INACTIVE state”. Is the intention of the proposal to say that RAN1 is not going to work on how to support and report the DL measurements by RRC\_INACTIVE UEs? |
| vivo | On the first part, our understanding if that there’s specification impact in RAN1 (at lease the measurement definition) for UE to measure DL PRS in RRC\_INACTIVE state. Not sure that should be part of RAN2’s work. |
| Qualcomm | Changing the 38.215 definition can happen within RAN1, and could happen with a simple CR in later phases |
| Nokia/NSB | Do not support. The RAN1 measurement definition in 38.215 needs to be updated for RRC\_Inactive UEs. |
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## Aspect #8. Configuration of DL-PRS for UEs in RRC\_INACTIVE state

The following views were expressed by selected companies with respect to configuration of DL PRS for RRC\_INACTIVE UEs:

* [vivo, [19]]:
* Validity of DL-PRS configuration on RRC\_INACTIVE state
* Update of DL-PRS configuration w/o change of RRC state (e.g. turn on/off)
* Reuse of QCL configuration in RRC\_INACTIVE state
* Processing of PRS and other DL signals (e.g. SSB, SIB1, COREST0, MSG2/MSGB, paging, etc.) by RRC\_INACTIVE UEs
* [Xiaomi, [32]]:
* Consider to pre-configure the PRS for inactive UE when UE is in connected mode

**FL Response**

* Aspects of DL PRS configuration for RRC\_INACTIVE UEs can be directly discussed in RAN2.

Companies are invited to provide views on FL response:

|  |  |
| --- | --- |
| Company Name | Comments |
| vivo | Our understanding is that there may be RAN1 aspects (e.g., UE behaviour) w.r.t. DL-PRS configuration for RRC\_INACTIVE state measurement/report which is not within RAN2’s scope. |
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## Aspect #9: DL indication to initiate UE measurements

The following view was expressed by company with respect to signaling for initiation of DL PRS measurements by RRC\_INACTIVE UEs:

* [InterDigital, [25]]:
* Support transmission of DL indication to UE for initiating measurement of preconfigured PRS when in INACTIVE using paging/RACH procedure

**FL Response**

* Continue discussion on indication of DL PRS measurement and report by RRC\_INACTIVE UEs

Companies are invited to provide views on FL response:

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| Company Name | Comments |
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## Aspect #10: Reporting by RRC\_INACTIVE UEs

The following views were expressed with respect to reporting by RRC\_INACTIVE UEs:

* [vivo, [19]]: UE report size optimization (e.g. compressing or allocation of suitable size)
* [InterDigital, [25]]:
* Support UE reporting when the UE observes changes in its measurements during INACTIVE positioning
* Support aperiodic measurement reporting during INACTIVE positioning
* [Xiaomi, [32]]: Measurement report can be sent to gNB by PUSCH in Msg 3 or Msg A during random access procedure for inactive UE.

**FL Response**

* As a first step, it is recommended to discuss and agree on measurements that can be done by RRC\_INACTIVE UEs

Companies are invited to provide views on FL response:

|  |  |
| --- | --- |
| Company Name | Comments |
| Nokia/NSB | Support in general. We prefer to make at least the DL RSTD and DL PRS-RSRP measurements applicable for the RRC\_INACTIVE state |
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## Aspect #11: PRS/SRS relationship with BWP0

The following views were expressed in terms of DL PRS and SRS relationship with initial BWP

* [Huawei, [31]]: Support a separate positioning bandwidth configuration from that of BWP#0 configured by the system information for SRS transmission in RRC\_INACTIVE.
* [vivo, [19]]: The relationship between PRS measurement and initial DL BWP should be further studied, e.g. including
* how to support UE to process PRS outside the initial DL BWP and/or PRS whose SCS is different with the initial DL BWP

**FL Response**

* SRS/PRS relationship with initial BWP for RRC\_INACTIVE UEs can be studied further

Companies are invited to provide views on FL response:

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| Company Name | Comments |
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## Aspect #12: UE capability for NR positioning in RRC\_INACTIVE state

One source has mentioned that UE capability for NR positioning in RRC\_INACTIVE state needs to be defined.

* [vivo, [19]]: UE positioning measurements, DL PRS processing capability in RRC\_INACTIVE state

**FL Response**

* UE capability can be discussed at a later stage when NR positioning support by RRC\_INACTIVE UEs is finalized or at least more design progress is made.

Companies are invited to provide views on FL response:

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| Company Name | Comments |
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## Aspect #13: Transparency of RRC state to LMF

One source expressed view on transparency of RRC state to LMF

* [InterDigital, [25]]: State of the UE (CONNECTED or INACTIVE) is transparent to the LMF and it does not affect the accuracy of the positioning requirement

**FL Response**

* This aspect seems to be under RAN2 scope. Suggest discussing it further in RAN2

Companies are invited to provide views on FL response:

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| Company Name | Comments |
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On-Demand DL PRS Support

## Aspect #1: On-demand PRS support

Two options for on-demand DL PRS support were discussed in [OPPO] and [vivo, [19]]:

* For Rel-17 on-demand PRS, down select one of the following alternatives:
* Alt.1: Pre-configuration based solution
  + Multiple DL PRS configurations are pre-configured/signaled
  + UE requests an on-demand PRS by indicating its preferred DL PRS configuration(s) (e.g., via an index)
  + LMF indicates gNB/TRP to activate one of these DL PRS configurations
* Alt.2: Non-pre-configuration-based solution
  + UE requests an on-demand PRS by indicating its preferred value(s) of some DL PRS parameter(s)
  + LMF indicates gNB/TRP to apply a DL PRS configuration with some given value(s) for some DL PRS parameter(s)
* [vivo, [19]]: Support the following configurations of on-demand PRS:
* Basic PRS configurations in different configuration levels
* Multiple on-demand PRS configurations in different configuration levels

### Round #1

The initial discussion for support of on-demand DL PRS was mainly about providing / requesting by UE/LMF certain set of DL PRS parameters. If it is agreed that UE can be preconfigured with multiple DL PRS configurations, then signaling of configuration ID may be also relevant to on-demand DL PRS support. In general, the discussed above alternatives may not be mutually exclusive. Therefore, it is recommended to discuss the following proposal:

**Proposal 5.1-1**

* + NR supports pre-configuration of multiple DL PRS configurations to UE
    - UE can indicate its preferred DL PRS configuration ID as a part of UE initiated on-demand DL PRS request

Companies are invited to express views on above proposal:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | Support in principle. May need further discussion on which of the parameters can be pre-configured. |
| Qualcomm | We want both 5.1 and 5.2 to be discussed together, or at least support them in principle together. Each one may be applicable to difference scenarios:   * Scenario 1: The UE has no information on possible on-demand DL-PRS configurations available * Scenario 2: The UE has one or more preconfigured or predefined DL-PRS configurations available |
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## Aspect #2: DL PRS parameters for on-demand UE / LMF initiated request

The major topic of discussion for on-demand DL PRS support is the list of parameters indicated during the UE/LMF initiated on-demand DL PRS signalling. The following views were expressed:

* [vivo, [19]]:
* It is up to RAN1 to decide specific parameters (e.g. PRS pattern, periodicity, BW, etc) for LMF-initiated and UE-initiated request of on-demand PRS.
* To support LMF-initiated request of on-demand DL-PRS, the measurement results and location can be reported and/or requested to be reported for UE-based mode.
* [CATT, [20]]:
* For UE-initiated on-demand DL PRS, the UE may provide the following information to the gNB and/or LMF when the UE sends an on-demand PRS request to the LMF:
  + The requested DL PRS resources in the time and frequency domain, and/or the QoS parameters related to target positioning performance (e.g., the start time, duration, periodicity, repetition number of PRS resources, etc.) to help gNBs to allocate DL PRS resources properly.
* For LMF-initiated on-demand DL PRS, the LMF may provide the following information to a gNB when the LMF sends the request to the gNB:
  + The requested DL PRS resources in the time and frequency domain, and/or the QoS parameters related to target positioning performance (e.g., the start time, duration, periodicity, repetition number of PRS resources, etc.) to help the gNB to allocate DL PRS resources properly.
* ZTE: RAN1 should discuss and consider the following PRS parameters which can be requested/suggested/recommended by UE or LMF.
* Parameters for frequency layer configuration
* Parameters for TRP configuration
* Parameters for PRS resource set configuration
* Parameters for PRS resource configuration
* Parameters for time domain attribute including aperiodic or periodic PRS
* [Qualcomm, [23]]: Requested DL-PRS configuration information

|  |  |  |
| --- | --- | --- |
| Information | UE-Initiated | LMF-Initiated |
| DL-PRS Start Time and Duration | Yes | Yes |
| Desired Number of TRPs | Yes | No |
| SSB Configuration for requested TRPs | Yes | No |
| Desired Beam Direction | Yes | No |
| CHOICE A: Pre-defined Configuration: |  |  |
| DL-PRS Configuration Identifier | Yes | Yes |
| COICE B: DL-PRS Configuration Parameter: |  |  |
| Maximum Number of Frequency Layers | Yes | Yes |
| DL-PRS Positioning Frequency Layer Information: |  |  |
| DL-PRS Subcarrier Spacing | No | No |
| DL-PRS Resource Bandwidth | Yes | Yes |
| DL-PRS Start PRB | No | No |
| DL-PRS PointA | No | No |
| DL-PRS Comb Size N | No | Yes |
| DL-PRS Cyclic Prefix | No | No |
| DL-PRS Configuration per Frequency Layer: |  |  |
| DL-PRS ID / PCI, ARFCN / NCGI | Yes | No |
| Maximum Number of DL-PRS Resource Sets | Yes | Yes |
| DL-PRS Resource Set Information: |  |  |
| DL-PRS Resource Set ID | Yes | Yes |
| DL-PRS Periodicity and Resource Set Slot Offset | Yes | Yes |
| DL-PRS Resource Repetition Factor | Yes | Yes |
| DL-PRS Resource Time Gap | Yes | Yes |
| DL-PRS Number of Symbols | Yes | Yes |
| DL-PRS Muting Option 1 | No | Yes |
| DL-PRS Muting Option 2 | No | Yes |
| DL-PRS Resource Power | No | Yes |
| Maximum Number of DL-PRS Resources per Set | Yes | Yes |
| DL-PRS Resource Information: |  |  |
| DL-PRS Resource ID | Yes | Yes |
| DL-PRS Sequence ID | No | Yes |
| DL-PRS RE Offset | No | Yes |
| DL-PRS Resource Slot Offset | No | Yes |
| DL-PRS Resource Symbol Offset | No | Yes |
| DL-PRS QCL-Info | Yes | Yes |

* OPPO: For Rel-17 on-demand PRS, the following parameters can be considered for the UE/LMF request signaling:
* The start time and duration (validity window)
* TRP information
* Positioning Frequency layer (PFL) information
* Periodicity
* Repetition
* Number of symbols
* Bandwidth
* Muting pattern
* QCL information
* [Intel, [27]]: For support of on-demand DL PRS transmission framework support signaling of the following parameters recommended by UE or LMF:
* Bandwidth of DL-PRS frequency layer / frequency layer
* DL-PRS transmission periodicity
* Time offset for DL-PRS transmission (e.g. specific time interval for DL PRS transmission)
* DL-PRS resource configuration parameters (e.g. number of symbols, repetitions, comb-factor)
* Set of TRPs, DL-PRS resource set IDs, DL PRS resource IDs and DL PRS muting (on/off) patterns
* [InterDigital, [25]]: For on-demand PRS, the UE can explicitly request PRS parameter(s) a specific parameter(s) or implicitly request PRS parameter(s) by sending assistance information. The UE includes at least the following parameters to the LMF as part of on-demand PRS request: Periodicity, Comb-pattern, Muting pattern, PRS resource ID
* [Nokia, [30]]:
* UE to LMF reported parameters include beam-specific measurement reports that assist the LMF determine and request certain PRS resources to the gNB.
* Requested PRS parameters include PRS bandwidth, number of consecutive subframes within a positioning occasion and PRS periodicity (periodicity of positioning occasions). PRS parameters can be requested either by UE to LMF (case of UE-initiated on-demand PRS), or by LMF to gNB (case of LMF-initiated and UE-initiated on-demand PRS).
* [Mediatek, [33]]: Support dynamic symbol number configuration for each comb type of Rel-16 DL-PRS for on-demand transmission, and UE may request the symbol number

### Round #1

**Proposal 5.2-1**

* + At least the following information is signaled for UE- and LMF- initiated on-demand DL PRS request
    1. Start/end time of DL PRS transmission
    2. DL PRS resource bandwidth
    3. DL-PRS resource set IDs
    4. DL PRS resource IDs
    5. DL PRS transmission periodicity and offset
    6. DL PRS resource repetition factor
    7. Number of DL PRS symbols per DL PRS resource
    8. DL PRS muting patterns
    9. DL PRS QCL information
  + FFS additional parameters indicated for UE and/or LMF initiated on-demand DL PRS request

Companies are invited to provide views on preferred set of parameters indicated for on-demand DL-PRS:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | Support in principle. Some of them may be optional (e.g., with some default values if not requested). |
| Qualcomm | For the “Resource IDs/Resource Set IDs”: Does this correspond to the case of pre-configured PRS? If there is no preconfiguration, what does it mean the UE to pick resource/set IDs? If that is the understanding, then also the TRP ID and PFL ID is missing.  For the “Muting pattern”: This typically is deployment-based, and having a UE requesting a specific muting pattern, may not be very useful.  “Number of TRPs” is missing and we consider it useful to be able to be requested by the UE. E.g. if the AD has a very small number of TRPs inside, a UE should be able to request for more TRPs to be activated.  “Number of PRS resources per PRS resource set” will be useful also for DL-AoD methods.  Similarly, “number frequency layers” is missing. A UE/LMF may want to get additional robustness/diversity by employing multiple frequency layers.  Similarly, request of desired beam directions is missing: This will be different than QCL information. QCL information is about requesting a PRS QCLed with a specific SSB, without knowing what direction that SSB is. Requesting a desired beam direction would correspond to the case that a UE/LMF requests a beam in a specific direction in GCS. |
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## Aspect #3 UE/gNB measurements & on-demand DL PRS support

* [CATT, [20]]:
* For UE-initiated on-demand DL PRS, the UE may provide the following information to the gNB and/or LMF when the UE sends an on-demand PRS request to the LMF:
  + DL measurements available in UE, which may include SS-RSRP, CSI-RSRP, etc., measured from the serving gNB and neighboring gNBs;
* When a serving gNB sends the response to LMF-initiated on-demand DL PRS for a UE, the serving gNB may provide the following information to the LMF in addition to the allocated DL PRS resources for supporting the on-demand DL PRS:
  + DL measurements reported by the UE if available at the gNB, which may include SS-RSRP, CSI-RSRP, etc., measured from the DL RS of serving gNB and neighboring gNBs;
  + UL measurements related to the UE if available at the gNB, which may include SRS-RSRP, etc., measured by the serving gNB.
* [InterDigital, [25]]: Discuss details about measurement reports for on-demand PRS.
* [Nokia, [30]]:
* UE feedback for on-demand PRS does not necessarily need UE support for new measurements; existing measurements can be reused instead. However, new configurations on existing measurements might be needed, which account for reporting a sufficiently large set of PRS resource per TRP measurements as part of UE feedback for on-demand PRS.

### Round #1

**Proposal 5.3-1**

* + Select one of the following alternatives
    - Alt.1 Reporting of UE/gNB measurements based on CSI-RS, SSB / SRS respectively is supported for on-demand DL PRS framework
      * FFS details
    - Alt.2 Reporting of UE/gNB measurements based on CSI-RS, SSB / SRS respectively is not supported for on-demand DL PRS framework

Companies are invited to provide comments on above proposal:

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| Company Name | Comments |
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## Aspect #4: Aperiodic/semi-persistent on-demand PRS

The following views were expressed with respect to support of on-demand PRS

* [InterDigital, [25]]: Support aperiodic and semi-persistent PRS for on-demand PRS.
* [vivo, [19]]: For ON/OFF request of on-demand PRS, at least support the following two interpretations:
* A basic ON/OFF request of on-demand PRS
* A finer level ON/OFF request of on-demand PRS in frequency layer, resource set and resource level
* ON request of on-demand PRS means to start the transmission of on-demand PRS.
* OFF request of on-demand PRS means to turn off the transmission of on-demand PRS and fallback to the transmission of PRS with basic configurations.
* [CMCC, [22]]: NR positioning should support the physical-layer procedures to trigger the on-demand DL PRS configurations.

**FL response:**

* Support of aperiodic and semi-perstistent like DL-PRS transmission with on/off signaling can be discussed in more general context including latency and DL PRS overhead reduction relative to periodic transmissions.
* Signaling of ON/OFF indication can be discussed as a part of on-demand DL parameters indication.

Companies are invited to provide views on preferred set of parameters indicated for on-demand DL-PRS:

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| Company Name | Comments |
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## Aspect #5: On-demand measurement gap

In [vivo, [19]], it was mentioned that LMF may request measurment gap:

* vivo: Support to introduce on-demand measurement gap for on-demand PRS in Rel-17.
* LMF requests measurement gap should be supported.

**FL response:**

* The allocation of dynamic measurmeent gap for positioning can be discussed in more general context. It is recommended to wait for more progress with respect to MG support in Rel.17 before discussing this aspect

Companies are invited to provide views on preferred set of parameters indicated for on-demand DL-PRS:

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| Company Name | Comments |
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## Aspect #6: AoD/ZoD assistance and on-demand PRS

The signalling of AoD/ZoD expected angles and uncertainties was discussed in [Nokia, [30]]

* [Nokia, [30]]:
* Support of indication of expected AoD/ZoD value and uncertainty (of the expected AoD/ZoD value) range(s) is signaled by the LMF to gNBs/TRPs at least for LMF-initiated on-demand PRS.

The related discussion is ongoing in DL-AOD agenda item.

**FL response:**

* It is recommended to have single discussion on AoD/ZoD signaling and continue discussing it in DL-AOD agenda item

Companies are invited to provide views on preferred set of parameters indicated for on-demand DL-PRS:

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| Company Name | Comments |
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Conclusion

In this contribution, we provided review of the submitted contributions for NR Positioning UL-AOA enhancements RRC\_INACTIVE UEs, on-demand DL PRS and prepared initial set of proposals to facilitate further discussion/decision by RAN WG1 during the RAN1#105e meeting.

References

1. R1-2104278 Enhancement for UL AoA positioning Huawei, HiSilicon
2. R1-2104360 Discussion on potential enhancements for UL-AoA method vivo
3. R1-2104521 Discussion on accuracy improvements for UL-AoA positioning solutions CATT
4. R1-2104591 Accuracy improvement for UL-AoA positioning solutions ZTE
5. R1-2104612 Discussion on UL-AoA enhancements CMCC
6. R1-2104672 Potential Enhancements on UL-AOA positioning Qualcomm Incorporated
7. R1-2104740 Enhancements for UL AoA Positioning OPPO
8. R1-2104872 Discussion on enhancements for UL-AoA positioning solutions InterDigital, Inc.
9. R1-2104906 NR Positioning UL-AoA Enhancements Intel Corporation
10. R1-2105106 Positioning Accuracy enhancements for UL-AoA Apple
11. R1-2105169 Discussion on accuracy improvements for UL-AoA positioning method Sony
12. R1-2105311 Discussion on accuracy improvements for UL-AoA positioning solutions Samsung
13. R1-2105483 Discussion on accuracy improvement for UL-AoA positioning LG Electronics
14. R1-2105513 Views on enhancing UL AoA Nokia, Nokia Shanghai Bell
15. R1-2105658 Discussion on UL AoA positioning enhancements PML
16. R1-2105700 Discussion on UL-AoA positioning enhancements NTT DOCOMO, INC.
17. R1-2105857 UL-AoA positioning enhancements Fraunhofer IIS, Fraunhofer HHI
18. R1-2105909 Enhancements of UL-AoA positioning solutions Ericsson
19. R1-2104364 Discussion on inactive state positioning and on-demand PRS vivo
20. R1-2104525 Discussion on on-demand transmission and reception of DL PRS and positioning solutions for UEs in RRC\_ INACTIVE state CATT
21. R1-2104595 Discussion on items led by RAN2 for NR positioning ZTE
22. R1-2104615 Discussion on NW/UE efficiency enhancements CMCC
23. R1-2104676 Enhancements Related to On Demand PRS And Positioning in RRC Inactive State Qualcomm Incorporated
24. R1-2104744 Discussion on positioning for UE in RRC\_INACTIVE and on-demand PRS OPPO
25. R1-2104876 Discussion on on-demand PRS and INACTIVE mode positioning InterDigital, Inc.
26. R1-2104880 Carrier/Subcarrier Phase Based Enhancement for 5G NR Positioning DanKook University
27. R1-2104910 Support of On-demand DL PRS and NR Positioning for UEs in RRC-INACTIVE state Intel Corporation
28. R1-2105315 Discussion on positioning in inactive state Samsung
29. R1-2105487 Discussion on other enhancements for positioning LG Electronics
30. R1-2105517 Additional views on Inactive Mode Positioning and on-demand PRS Nokia, Nokia Shanghai Bell
31. R1-2105534 Discussion on UL and DL+UL positioning in INACTIVE state Huawei, HiSilicon
32. R1-2105566 On-demand PRS and positioning for in-active state UE Xiaomi
33. R1-2105892 Potential physical layer impact to the RAN2-led topics MediaTek Inc.
34. R1-2105913 On-demand transmission and reception of DL PRS for DL and DL+UL positioning Ericsson