**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

## Round #2

In this section, for each topic we provide guidance in terms of priority of discussion in the second round. It is proposed to focus on discussion for the following design aspects given that of UL-AOA Aspects #1, 2, 3, 5 were already resolved.

* UL-AOA Enhancements - Section 3
* Aspect #6: UL-AOA Report per SRS for Positioning Resource / Resource Set
* Aspect #7: Number of Reported UL-AOA Values for the First Arrival Path
* 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 #2: DL PRS Parameters for On-demand UE / LMF Initiated Request
* Note: Aspect 1 was merged to Aspect 2 based on received feedback

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.

|  |
| --- |
| * 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 8 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]], [Sony, [11]], [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

|  |  |
| --- | --- |
| 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 |
| ZTE | Prefer GCS. |
| Samsung  | If we go with alt.2, does it mean we need further define in what condition and what signalling to indicate current report in LCS or GCS? |
| LG | Support. |
| Huawei, HiSilicon | Prefer GCS-only. Fine to accept GCS+LCS for the sake of progress. |
| Fraunhofer | Support |
| vivo | Sorry, we prefer Alt.1. But, if it is the preferences of the majority, we can compromise with the following modification since LMF does not always have the LCS to GCS translation information.* Only GCS is supported for UL AoA/ZoA assistance information indication if the LCS to GCS translation information is unknown in LMF
* Both GCS and LCS are supported for UL AoA/ZoA assistance information indication if the LCS to GCS translation information is known in LMF

. |
| Intel | Support  |
| Sony | Support |
| Ericsson | We still think that the support of both signalling is overkill for what we want to achieve, and would prefer alt1. However, if this issue can be closed, we can accept to have both options supported.  |

## 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

|  |  |
| --- | --- |
| 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. |
| ZTE | Support |
| InterDigital | We support the proposal from the FL. |
| Samsung  | support |
| LG | Support. |
| NTT DOCOMO | Support |
| Huawei, HiSilicon | Support. |
| Fraunhofer | Support |
| vivo | We acknowledge the point made by some companies that TRP INFORMATION REQUEST is independent of the positioning method, then we cannot exclude the information that is used in other methods. But, similarly, it is not necessary to explicitly support the signaling of AoA/ZoA assistance information for UL-TDOA and Multi-RTT positioning methods.In addition, if the proposal is supported, maybe there is no additional spec work in the 38.455. But TS 38.305 needs to be revised since the information is associated with the positioning method. That is, the UL AoA/ZoA assistance information should be added in 8.10.2(RTT), 8.13.2(UL-TDOA), 8.14.2(UL-AOA),which is weird for us.However, the benefit of using the UL AoA/ZoA assistance information in UL-TDOA and Multi-RTT is unclear. So we cannot agree with it. |
| Intel | Support  |
| Sony | Support. The expected value and uncertainty range can help TRP determining the bore sight direction to a UE. The beam toward this direction obtains the maximum beam forming gain.  |
| Apple | Do not support. We share similar view as vivo. To us, such assistance information is more some side information, where benefit for timing based positioning techniques is not justified. |
| Nokia/NSB | To vivo and Apple: In our view, it is beneficial to decide beam direction at least for UL-only RP. UL-only RP might not be capable of spatial relation configuration. |
| vivo 2 | Yes, maybe it is beneficial for UL-only RP.But we would like to provide an example that expected AoA may be harmful to Multi-RTT.In the current spec, the PRS can be configured with a QCL signal and SRS can be configured with a spatial relationship signal. Uplink channel and downlink channel can be more consistent when the spatial relationship/ QCL is the same. And we think it is logical that the spatial relationship signal is configured in pairs for DL and ULBut, if selecting Rx beam based on LOS direction on the gNB side, it may corrupt the consistency of UL and DL channels. And the strongest path may be different for different Rx beams, so the additional error may introduce if the strongest path is different paths in DL and UL.Quoting the following figure of QC to illustrate , if the strongest path is different paths in DL and UL, the additional error will introduce. |
| Ericsson | Support  |

## 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

|  |  |
| --- | --- |
| Company Name | Comments |
|  | Granularity of AOA/ZOAValue 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. |
| ZTE | Support |
| Samsung  | Just to clarify, how does this 0.1 degree come from? |
| LG | Support, To Samsung, 0.1 degree is granularity of AoA/ZoA in current specification.  |
| Huawei, HiSilicon | OK |
| Fraunhofer | We have similar views to CATT (Low priority) |
| vivo | Whether we need to modify expected ZoA (θAOA ) to expected ZoA (θZOA ), and the same problem was in our previous agreement |
| Intel | Support  |
| Sony | Support |
| Ericsson | Support  |

## 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 |
| LG | Agree. |
| Fraunhofer | As discussed in [17] the proposal is complementary to the last meeting agreement for the following reasons:* In some scenarios when the DL-PRS beam indication is more accurate than an expected UL AoA/ZoA estimated based on a UE position
* The TRP will not be able to derive the information from the SRS-configuration if the UE is not configured with SRS-spatial-relation towards a given TRP
* The LMF doesn’t necessarily know the beam direction of the DL-PRS resources (e.g. in case DL-AOD is not supported)
* Option 2 has minor spec impact:

In NRRPa, the TRP can provide the LMF with *Measurement-Beam-Information* on the TRP-Rx-beam direction used for UL-SRS measurement by indicating a DL-PRS or an SSB.To bring discussion forward, what about including the option in LS and leave it for RAN3 to decide, simply:**RAN1 discussed providing the TRP with DL-PRS resource as an AoA/ZoA and uncertainty range information(similar to *Measurement-Beam-Information*). Whether or not the LMF is to provide the TRP with DL-PRS resource information is up to RAN3 decision.**  |
| vivo | Support |
| Sony | We consider additional signalling is still needed, such as the duration how long the TRP can still use the UL AoA/ZoA assistance information. |
| Apple | Support FL’s proposal |
|  |  |

## 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

|  |  |
| --- | --- |
| 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. |
| ZTE | Support |
| LG | Support. |
| NTT DOCOMO | Support |
| Huawei, HiSilicon | OK |
| Fraunhofer | Support including our proposal on 3.4-1 |
| vivo | Support |
| Intel | Support  |
| Sony | Support |
| Apple | Support |

## 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

|  |  |
| --- | --- |
| 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. |
| ZTE | We think we should discuss whether UL-AOA measurement report should also include SRS resource ID/resource set ID rather than select among those two options. |
| LG | Support option 1. In general, the proposal is also dealt in the FFS of proposal 3.9.1, we prefer to merge the proposal into proposal 3.9.1.  |
| Huawei, HiSilicon | In our view, UL-TDOA/Multi-RTT should allow TRP to report the measurement association with SRS resource (if the SRS resource is associated with the TEG), UL AoA can also adopt a similar reporting behaviour.In this sense, we can support Option 1. However, this is about gNB behaviour, we do not want to limit it to positioning SRS. |
| Fraunhofer | Support Option1 |
| vivo | Support Option1. The same view with CATT and Nokia. |
| Intel | Option 1 |
| Sony | Option 1 |
| Apple | Support Option 1 |
| Ericsson | Agree with Huawei, the gNB could measure both the SRSpos and the SRS “for MIMO”. Support reporting the SRS at the resource level, but also include the resource set in the report to allow to measure and report across resource sets.  |

It seems there is a consensus to support Option 1. In needs to be further discussed whether gNB is expected to report UL-AOA/ZOA measurements for all SRS for positioning resources within SRS for positioning resource set. In addition, it needs to be discussed/concluded whether the it is also supported for MIMO SRS.

### Round #2

Companies are invited to provide views on the revised proposal for UL-AOA measurement report supported by gNB. The SRS for MIMO is added in brackets since not many companies have expressed their views on this aspect. Please express the view on SRS for MIMO in the 2nd round.

**Proposal 3.6-1**

* NR supports gNB reporting of the first arrival path UL-AOA/ZOA measurement per SRS for positioning resource [and SRS for MIMO resource]
	+ FFS whether gNB reports UL-AOA/ZOA measurement for all resources of resource set

Views from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| Qualcomm | Support (OK for SRS for MIMO also) |
| Nokia/NSB | Support. From our side, the motivation of SRS resource level reporting was that the measurements could be different depending on the beam direction. For a similar reason, resource level reporting is also reasonable for SRS for MIMO. |
| Ericsson | Support. We are ok to include SRS for MIMO in the agreement (i.e. remove the brackets) |
| ZTE | In 8.5.1, we have passed the following agreement for UL-TDOA,* Support gNB to report the associated SRS resource ID/resource set ID of the RTOA measurement to LMF

We’re generally fine with the proposal. However, we think we should use similar formulation as we agreed in 8.5.1. |
| Huawei, HiSilicon | We just would like to clarify that the proposal 3.6-1 is meant to say that SRS Resource/Positioning SRS resource ID can be reported for an UL-AoA measurement. And the FFS part is meant to say that SRS Resource/Positioning SRS resource set ID can be reported for an UL-AoA measurement.If it is the correct understanding, we support the proposal. |
| OPPO | Quesiton on the FFS part: does it intend to say that UL-AoA/ZoA measurement for first arrival path of each SRS resource in the set?And not ok with the SRS for MIMO part. If it is included, does it cause any change of UE behavior on transmitting SRS for MIMO? |
| Huawei, HiSilicon | To OPPO: No, because it is transparent to the UE, similar to Rel-16. |
| NTT DOCOMO | Support. We are fine with removing brackets. |
| LG | Support. |
| Sony | Support but keep the bracket. At least someone can clarify: On “[and SRS for MIMO resource]”, Does it mean we support SRS for MIMO to be used for UL-AoA positioning purpose? |
| CATT | Support. Share the similar view as ZTE and Huawei. It might be cleaer to say SRS Resource/Positioning SRS resource ID can be reported for an UL-AoA measurement. |

## Aspect #7: Number of Reported UL-AOA Values for the First Arrival Path

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. |
| ZTE | Support {1, 2}. We think the intention to support mutiple UL-AOA values is to address the case when beam pattern have multiple lobes (e.g. antenna spacing is larger than lambda/2). So, we think up to 2 is enough. |
| Huawei, HiSilicon | OK to keep values less than or equal to 4. |
| Ericsson |  If this is the maximum value from the LMF point of view, the number could be much higher. For clarification, is the value intended per measured SRS resource or across measured resources? |

Based on discussion, companies have different preference

* Remove 6 and 8: CATT, Nokia, Huawei,
* Support 1 and 2: ZTE
* Support more than 4: Quaclomm, Ericsson

Considering that the intention is to indicate the maximum number and gNB decides on amount of values (less than maximum), it is not clear why numbers more than 4 are concerned.

### Round #2

Companies are invited to provide views on the revised proposal for UL-AOA measurement report and clarify why maximum number should be less than or equal to 4, considering massive MIMO antenna arrays.

**Proposal 3.7-2**

* LMF indicates maximum number of UL-AOAs values (pair of AOA & ZOA values) for the first arrival path corresponding to the same timestamp
	+ The maximum number is selected from the set {1, 2, 4, [X1 > 4], [X2 > 8]}
	+ FFS value of X1 and X2

Views from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| Qualcomm | We support having X1>4 agreed together with the smaller values.  |
| Nokia/NSB | Support. We are still questionable about the necessity for more than 4. Can any proponent clarify the use case? |
| Ericsson | Support. We think having more than 4 values would allow to reports ambiguities over multiple sets.  |
| ZTE | We think we should come back after Aspect#6 has been agreed. Because we’re not sure the “maximum number of UL-AOAs values (pair of AOA & ZOA values) for the first arrival path corresponding to the same timestamp” mentioned here is talking about,* The maximum number per SRS resource, or
* The maximum number per SRS resource set, or
* The maximum number per measurement report

For the maximum number per SRS resource, we think support 1 and 2 is enough. |
| Huawei, HiSilicon | Support. |
| OPPO | Support |
| LG | Support. |
| Sony  | We support the maximum number = 2 for each measurement report. If the intention of the proposal is to solve the ambiguity by having larger than half wavelength element spacing, then 2 is sufficient.  |
| vivo | We think the maximum number is for one SRS resource, the multiple measurement values associated with the first arrival path corresponding to the same timestamp occurs in the following cases based on the perious discussion:* Case 1 NLOS case
* Case 2 ambiguity between frontside and backside directions
* Case 3 ambiguity because of larger antenna spacing

We would like to understand in which case the maximum number can exceed 2 or 4.Otherwise, we prefer to put 4 in bracket* + The maximum number is selected from the set {1, 2, ~~4,~~ [X1$\geq $ 4], [X2 > 8]}
 |
| CATT | We are fine of the proposal, although we prefer vivo’s modification. In our view, it only makes sense for X1>4 if we can show the 4 UL-AOA valuess of the 1st path could be all wrong, and more than 4 UL-AOAs of the 1st path could significantly include the chance that one of the reported UL-AOAs is correct. |
|  |  |

## 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. |
| ZTE | Discuss together in AI 8.5.1. |
| LG | In currently, the discussion on reference device has been discussed in various AIs. So, we prefer to discuss it in the specific AI and we have similar view with Nokia/NSB. |
| Huawei, HiSilicon | This should not be discussed in Al 8.5.1. Even if the reference device is adopted in implementation-specific method, such a signalling is still helpful. |
| Vivo | Agree with ZTE that it should be discussed in AI 8.5.1. |
| Sony | It should be discussed in AI 8.5.1 |
| Apple | Agree with majority to first discuss on reference device  |
| Ericsson | We should first agree on reference devices.  |

## 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:

|  |  |
| --- | --- |
| 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.  |
| ZTE | What’s the definition of RSRP of first arriving path needs to be clarified first. We may need to consult RAN4 whether gNB can be sensitive enough to measure path-RSRP.Don’t support second main bullet. This can already be supported by hybrid UL-AOA and UL-TDOA. |
| LG | We are generally fine with FL’s proposal. In addition, since the current definition of RSRP is not suitable for path specific, we think the definition of path specific RSRP needs to be clarified first and FFS needs to be remain. |
| Fraunhofer | Ok with proposal.  |
| vivo | For the first main bullet, we agree with Nokia and ZTE that the definition of path-specific RSRP should be clarified first.For the second main bullet, whether support enhancing AoA reporting with RTOA should be further discussed since only RSRP and angle of arrival reporting are supported in the current UL-AOA positioning. And we have a similar view with ZTE it can be supported by hybrid UL-AOA and UL-TDOA.Table 8.14.2.2-1: Measurement results that may be transferred from gNBs to the LMF

|  |
| --- |
| Measurement results |
| PCI, GCI, and TRP ID of the measurement |
| UL Angle of Arrival (azimuth and elevation) |
| UL-SRS-RSRP |
| Time stamp of the measurement |
| Quality for each measurement |

 |
| Sony | Only support the Alt1 in the first main bullet. For the second main bullet, we prefer to discuss it in the hybrid UL-AoA and UL-TDOA topic. |
| Apple | Support Alt1 and Alt3 (and combination of 1&3). Please be more specific on PosSRS as Rel-15 SRS can be discussed separately if justified for positioning  |
| Ericsson | Support the proposal, and prefer alt2 for both.   |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | RAN4 may need to be consulted on whether gNB is able to provide beam-specific ARP. |
| ZTE | To CATT, current spec in 38.455 already support the beam-specific ARP,1. Different DL PRS resources associated with different ARP within the same TRP can be transmitted with different beams(i.e. associated with different QCL sources).
2. Different UL-AOA values can be associated with different Measurement Beam Information (i.e. different receiving beams)

Therefore, both transmitting beam and receiving beam can be different for different ARPs. |
| Fraunhofer | We share the views with ZTE. In fact the unknown ARP information at the LMF will result in a delay-offset and for this we addressed the same issue in 8.5.1. |
|  |  |
|  |  |
|  |  |

## 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

|  |  |
| --- | --- |
| Company Name | Comments |
| ZTE | No need to enhance this since SRS can already be associated with spatial relation info. |
| LG | Support, To ZTE: even though spatial relation information is provided in the SRS configuration, we think that the spatial relation information is not reflect the current state/location of UE. The motivation is for UE to select SRS resource and adjust its Tx spatial beam with more efficiently. We are open to discuss the details of information and we are only proving some examples. We think it is one of the solutions and it has a similar reason of expected DL-AoD in AI 8.5.3.  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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.

|  |  |
| --- | --- |
| 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. |
| Huawei, HiSilicon | Shouldn’t it be up to TRP implementation? Or is Nokia proposing to report RSRP to the LMF and LMF calculates the UL-AoA? |
| Sony  | We also think this is TRP implementation aspect. |
| Nokia/NSB | To Huwawei/Hisilicon: Our intention is not the RSRP reporting from gNB to LMF, but LMF assists TRP to decide beam resolution to secure different RSRP values depending on the UE's location. For example, if the UE is located in between Tx beams, the TRP needs to use more narrow beam. We have a modified proposal: Proposal: Study LMF-assisted beam angle resolution control for the performance improvement of interpolation-based AoA method using RSRP. |
|  |  |
|  |  |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
| Nokia/NSB | It may be related to RAT-independent technique. We are not sure if it could be discussed in RAN1. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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:

|  |  |
| --- | --- |
| 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  |
| ZTE | Out of scope. |
| LG | We think it is out of scope. |
|  |  |

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:

|  |  |
| --- | --- |
| 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. |
| ZTE | Similar view as Nokia. |
| CMCC | Support |
| InterDigital | We support the proposal from the FL. |
| LG | Support. |
| Lenovo, Motorola Mobility | Generally supportive if time allows. |
| NTT DOCOMO | Support |
| Huawei, HiSilicon | Support.We believe SDT already supports SRB2 to carry the UL LCS/LPP message, which can be considered as the progress. |
| Intel  | Support  |
| Sony | Support |
| Apple | Do not support, out of scope  |

### Round #2

Companies seems agree with proposal. One company thinks that proposal is out of WI scope, which does not seem to be the case based on the latest revision of WID.

|  |
| --- |
| * UL and DL+UL NR positioning methods
* Support of gNB positioning measurements for UEs in RRC\_INACTIVE state
 |

Considering that there is no other concerns expressed and majority support for the Proposal 4.1-1, it seems reasonable to reiterate the Proposal 4.1-1 in Proposal 4.1-2 and continue discussion in case if there are any additional comments.

**Proposal 4.1-2**

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

|  |  |
| --- | --- |
| Company Name | Comments |
| vivo | Support |
| Qualcomm | Support |
| Nokia/NSB | We have the same comment. 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. |
| Ericsson | Agree with Nokia, it can be downprioritized.  |
| InterDigital | Support |
| ZTE | Similar view as Nokia. |
| Huawei, HiSilicon | Support.Comments to Nokia/Ericsson/ZTE, what process on DL are we talking about? What is the degree to which the progress in DL can be satisfactory to start UL? |
| CMCC | Support |
| OPPO | Similar view as Nokia and ZTE, this is low priority issue, as stated in WID. We shall at least wait for the discussion and outcome in RAN2 who lead the item of RRC\_inactive. |
| LG | Support. |
| SONY | Support |
| vivo 2 | SupportSimilar view as Huawei, there is no additional DL work that is identified from RAN1 except the modification in TS 38.215 and UE capability.But for SRS, it needs more efforts from RAN1. In addition, RAN2 has reached agreement just now to consider UL signal condiguration, we prefer to support the proposal to cooperate RAN2 work.Agreements:Any uplink LCS or LPP message can be transported in RRC\_INACTIVE from RAN2 perspective. Follow Rel-17 SDT framework for INACTIVE UL and DL positioning: If the UE initiated data transmission using UL SDT, the network can send DL LCS, LPP message and RRC message (e.g. to configure SRS (TBD on what message is used), if UL positioning supported) to the UE.  Otherwise, if UE did not initiate UL SDT, rely on legacy operation, i.e. the network shall transition the UE to RRC\_CONNECTED, e.g. based on RAN paging.  |
| CATT | Support |
|  |  |

## 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:

|  |  |
| --- | --- |
| 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. |
| ZTE | Similar view as Nokia. |
| CMCC | Regarding the 1st main bullet, we prefer options 2, 4, and 5, but OK to leave all these options for further study. We think that the LS can be sent later when RAN1 further down-scopes. |
| InterDigital | We are ok with the proposal from the FL. |
| LG | Support. |
| Lenovo, Motorola Mobility | Generally supportive if time allows. |
| Huawei, HiSilicon | Support. |
| Intel  | OK with the proposal from FL |
| Sony | Support.  |
| Apple | Do not support, out of scope  |

### Round #2

Majority of companies seems agree with original proposal. One company thinks that proposal is out of WI scope, which does not seem to be the case based on the latest revision of WID:

|  |
| --- |
| * UL and DL+UL NR positioning methods
* Support of gNB positioning measurements for UEs in RRC\_INACTIVE state
 |

Considering that there is no other concerns expressed and majority support for the Proposal 4.2-1, it seems reasonable to reiterate in Proposal 4.2-2 and further discuss whether RAN1 should send LS to RAN2 this meeting.

**Proposal 4.2-2**

* + 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 further views including position with respect to RAN1 LS to RAN2.

|  |  |
| --- | --- |
| Company Name | Comments |
| vivo | As stated in our comment in the 1st round, we support the 1st bullet.On the 2nd bullet of sending LS to RAN2 on the list of options, we feel too early to send LS to RAN2 on this matter right now. |
| Qualcomm | We are OK to study these options. No need to send an LS.  |
| Nokia/NSB | We have the same comment. 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. Sending an LS is too early. We prefer to discuss later after making a consensus.  |
| Ericsson | We should not start discussing options before agreeing on the principle (in aspect 1).  |
| InterDigital | We support the FL’s proposal. Regardign the LS, we can wait until we narrrow down the options and determine whether the options have impact on RAN2 or not. |
| ZTE | Similar view as Nokia and Ericsson  |
| Huawei, HiSilicon | OK without the LS. |
| CMCC | Support for the 1st bullet. Share similar views with other companies that 2nd bullet is not needed at this stage. |
| OPPO | Do not support this proposal. Similar view as Nokia/ZTE/Ericsson. We shall at least wait for the discussion and outcome in RAN2 who lead the item of RRC\_inactive |
| LG | Agree. |
| SONY | Support. RAN1 can continue the study and LS is not needed. |
| Ericsson | We should not start discussing options before agreeing on the principle (in aspect 1).  |
| CATT | Support |

## 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:

|  |  |
| --- | --- |
| 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. |
| ZTE | Discuss DL first. |
| CMCC | We think that it can be further studied after more progress is made on Proposal 4.2-1. |
| InterDigital | We support the proposal from the FL. |
| LG | Okay. |
| Sony | It is OK to further study. |
| Apple | Do not support, out of scope  |
| Ericsson | We should wait for aspect #1 to converge.  |

## 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:

|  |  |
| --- | --- |
| 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. |
| ZTE | Discuss DL first. |
| CMCC | Support. |
| InterDigital | We are ok to come back to this topic. |
| LG | Support |
| vivo | OK. In addition to TA and OLPC related issues, spatial relation of SRS for positioning in inactive state should also be discussed. |

## 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:

|  |  |
| --- | --- |
| 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. |
| ZTE | Discuss DL first. |
| CMCC | Support. |
| InterDigital | We are ok to come back to this topic. |
| LG | Okay. |
| vivo | OK. In addition to TA and OLPC related issues, spatial relation of SRS for positioning in inactive state should also be discussed. |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
| CMCC | OK |
| LG | Okay |
| NTT DOCOMO | We are OK with FL’s suggestion. |
| Sony | OK |
| ZTE | OK |
|  |  |

## 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.

### Round #1

**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:

|  |  |
| --- | --- |
| 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. |
| ZTE | Decide by RAN2 first. If there is RAN1 impact, RAN2 can send LS. |
| InterDigital | The proposal can be clarified. RAN1 can discuss details of measurements (e.g., what the UE can measure). Reporting of measurements for positioning during RRC\_INACTIVE is already included in WID (RP-210903) to be supported and the note “this work will be coordinated with the SDT WI” is included. Details related to procedure and content of the measurement report can be discussed between RAN1 and RAN2. |
| LG | We have similar view with CATT. |
| Lenovo, Motorola Mobility | Agree with most companies that TS 38.215 would need to be updated. We also need to have a common understanding on whether the existing DL-PRS configuration (e.g. occasions, periodicity, offset, etc.) can be equally applicable in RRC\_INACTIVE state (e.g. if it can be aligned with the UE DRX configuration).  |
| Huawei, HiSilicon | Agree with QC that 215 change can be rather simple. |
| Intel  | Our understanding that DL measurements are already supported by WID objective:* DL NR positioning methods and RAT-independent positioning methods
	+ Support of UE positioning measurements for UEs in RRC\_INACTIVE state
	+ Reporting of positioning measurement or location estimate performed in RRC\_INACTIVE when the UE is in RRC\_INACTIVE state
* Note: this work will be coordinated with the SDT WI.

Therefore, we think that the major work should be done by RAN2 to defined the signaling of measurements reporting.  |
| Sony | We have similar view as Intel. |

### Round #2

It seems various companies think that RAN1 needs to work on support of UE DL positioning measurements for UEs in RRC\_INACTIVE state, while majority think that it can be further led by RAN2, except minor change in measurement definition.

To avoid potential misunderstanding among companies it is worthwhile to clarify what is the potential RAN1 scope to support DL NR positioning methods by RRC\_INACTIVE UEs?

**Question 4.7-2: What is the potential RAN1 scope to support DL NR positioning methods by RRC\_INACTIVE UEs besides adding RRC\_INACTIVE state to measurement definition?**

|  |  |
| --- | --- |
| Company Name | Comments |
| vivo | In addition to UE measurement definition, we think there might be potential RAN1 discussion/specification impact depends on RAN2 progress. For example, whether all or part of UE DL measurement report can fit into the payload of reporting mechanism defined by RAN2 (e.g., SDT). |
| Qualcomm | Just 38.215 change for now. More may identified in the future as RAN2 progresses. |
| InterDigital | We agree with the change in 38.215. We can wait for RAN2 feedback for possible specifiation impacts in RAN1. |
| ZTE |  It is better to wait for RAN2’s outcome.  |
| Huawei, HiSilicon | Our understanding is if we assume the same processing capability of PRS from CONNECTED is reused for INACTIVE state, there isn’t really much RAN1 should do besides the change of the 215 spec, which is quite trivial.Our confusion is that about Aspec #1, when Nokia/Ericsson/ZTE say they want to see progress in DL, what is the progress that they have in mind? |
| CMCC | We share similar views with companies that changes would be in 215 at the current stage. |
| OPPO | We shall wait for RAN2 dicussion.  |
| LG | As other companies have commented, we fully agree that the major work need to be done by RAN2 and higher layer. However, we think that RAN1 also needs to discuss simulatenouly what needs to be discussed/studied. Firstly, the LPP messages from LMF to UE (e.g. *RequestCapabilities, ProvideAssistanceData, RequestLocationInformation, etc*.) can be transmitted during paging procedure (PDCCH and/or PDSCH) and RACH procedure (msg2 and/or msg4, msgB). Likewise, LPP messages from UE to LMF (e.g. *ProvideCapabilities, RequestAssistanceData, ProvideLocationInformation, etc*.) also can be transmitted through RACH procedure (including SDT). In this sense, we believe that which physical channel is used for sending a message and how to define related procedure might be a discussion point in terms of RAN1 perspective. In addition, since the current measurement result to be reported can not be suitable for UEs in Inactive state becase of size, we think that RAN1 also might need to discuss which contents for measurement report are necessary or not. That is, some rules such as compression and priority rule for data also might be a RAN1’s issue. Furthermore, as new RACH procedure has been introduced for obtaing SRS configuration in the aspect #3, additional procedure(or new) (configuration of preamble and other related procedure) also can be treated as RAN1’s issue.The last example we think is the relation between DRX cycle and measurement it self (e.g. PRS/MG configuration). Like a above examples, we think that there might be a lot of points that RAN1 needs to discuss. Other than the examples listed above, we are open to discussion any RAN1 related issue. |
| SONY | Support. This topic is RAN2 led but we know there is RAN1 impact. RAN1 can continue the study and LS is not needed at the present stage. |
| CATT | We can wait for RAN2 feedback for possible specifiation impacts in RAN1. |
|  |  |

## 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.  |
| ZTE | OK |
| InterDigital | We agree with vivo that aspects related to UE behaviour, such as handling of configurations, can be discussed in RAN1. Configurations handover from CONNETED to INACTIVE or how it is conveyed to the UE can be discussed in RAN2. |
| LG | Agree with vivo’s comment. |
| Huawei, HiSilicon | For configuration, it can be directly discussed by RAN2. |
|  |  |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
| InterDigital | We are ok with the FL’s suggestion. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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 |
| ZTE | Support. |
| InterDigital | We are ok with the FL’s proposal. |
| LG | Support. |
| Sony | Support. We think RAN2 is currently discussing the reporting mechanism (e.g., using SDT). |
|  |  |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
| LG | Agree. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
| LG | Agree. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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:

|  |  |
| --- | --- |
| 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
 |
| CMCC | Support |
| InterDigital | We are fine with the nterdig. At least for some parameters. Pre-configured parameters will work with on-demand PRS, we believe the principle of the proposal can be agreed. As the details of this agreement may relate to the discussion in 5.2, onstead of “UE can indicate its preferred DL PRS configuration ID as a part of UE initiated on-demand DL PRS request”, we suggest the following proposal with FFS for the details:* + NR supports pre-configuration of multiple DL PRS configurations to UE
		- FFS : contents of pre-configurations, procedure for UE initiated on-demand DL PRS request (e.g., indicate the UE’s preferred DL PRS configuration ID), other details
		- ~~UE can indicate its preferred DL PRS configuration ID as a part of UE initiated on-demand DL PRS request~~
 |
| Samsung  | Fine with the intention. Fine the interdigital’s revision. |
| LG | We slightly prefer nterdigital’s revision. |
| Lenovo, Motorola Mobility  | Agree with FL’s proposal, but we also think that both Alt. 1 and Alt. 2 can be supported depending on the use case. |
| Huawei, HiSilicon | This is related to how the on-demand PRS framework is adopted. Currently whether we go with configuration ID, or parameter-specific request is not decided yet. Suggest to wait for RAN2 outcome. |
| Vivo | In general, we have a similar view with QC to discuss 5.1 and 5.2 together Because the bullet only is one of the methods for UE to request on-demand DL-PRS. And the request specific configuration should be considered based on our previous agreement

|  |
| --- |
| Agreement:* Semi-persistent and a-periodic transmission and reception of DL PRS will be investigated in Rel-17.
	+ FFS: the details on when and how to enable semi-persistent and a-periodic DL PRS
	+ FFS: to be supported for which positioning methods, e.g.,
		- UE-assisted and/or UE-based positioning
		- DL positioning and/or Multi-RTT
* On-demand transmission and reception of DL PRS will be investigated in Rel-17.
	+ FFS: the details on when and how to enable on-demand DL PRS
	+ FFS: to be supported for which positioning methods, e.g.,
		- UE-assisted and/or UE-based positioning
		- DL positioning and/or Multi-RTT
* Notes:
	+ Semi-persistent means MAC-CE triggered
	+ Aperiodic would correspond to DCI-triggered
	+ On-demand corresponds to the UE-initiated or network-initiated request of PRS and/or SRS. So, it is NOT the same as whether PRS is DCI-triggered or MAC-CE triggered. It is about UE or LMF request/suggesting/recommending specific PRS pattern, ON/OFF, periodicity, BW, etc.
 |

So, we propose * + 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
	+ UE/LMF can consider the following information as a part of UE/LMF initiated on-demand DL PRS request
		- ON/OFF on-demand PRS
		- DL PRS resource bandwidth
		- DL PRS resource periodicity
		- …
 |
| Intel  | Support  |
| Sony  | Support |
| Nokia/NSB | We are generally fine, but the core part of on-demand feature should be first discussed before agreeing this such as discussion on essential parameters of 5.2. It is also fine to discuss 5.2 together this issue. |

**Conclusion**

Considering that many companies want to discuss aspects 5.1 and 5.2 together, the aspect 5.1 is merged with aspect 5.2 in subsection 5.2.2. Discussion on Aspect 1 in section 5.1 is closed.

## 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.  |
| ZTE | OK with current proposal. |
| CMCC | Not sure about the relationship of this proposal with Proposal 5.1.1. It seems to us that this is related to the no-pre-configuration based solution. |
| InterDigital | We are fine with the proposal. As companies mentioned in their contributions, we suggest to rephrase “Start/end time of DL PRS transmission” to “DL PRS transmission with start time and end time/duration”. We do see values in including PRS muting pattern for on-demand for controlled PRS transmission to avoid collision (e.g., a UE can select a muting pattern from preconfigured muting patterns). |
| Samsung  | Support in principle. Similar question, do the listed parameters all be pre-configured? |
| Lenovo, Motorola Mobility | Support FL’s proposal. We also wonder if the TRP ID should be re-introduced to flexibly allow the on-demand DL-PRS request to be updated per TRP. |
| Huawei, HiSilicon |

|  |  |  |
| --- | --- | --- |
|  | UE initiated | LMF initiated |
| Start/end time of DL PRS transmission | No | Yes |
| DL PRS resource bandwidth | Yes | Yes |
| DL-PRS resource set IDs | No | Yes (In our understanding, this corresponds to ON/OFF of a specific PRS resource set.) |
| DL PRS resource IDs | No | Yes (In our understanding, this corresponds to ON/OFF of a specific PRS resource.) |
| DL PRS transmission periodicity and offset | Yes | Yes |
| DL PRS resource repetition factor | No | No |
| Number of DL PRS symbols per DL PRS resource | No | No |
| DL PRS muting patterns | No | No |
| DL PRS QCL information | Yes | No (Assuming TRP will also provide QCL information if available) |

 |
| vivo | The same view in 5.1. As we understand, this is the first discussion about the specific on-demand DL-PRS configuration, we prefer to modify the main bullet as “ considering the following information is signaled for UE- and LMF- initiated on-demand DL PRS request”. |
| Intel  | Support  |
| Sony | Support |
| Nokia/NSB | It is not sure if we need to introduce all of the parameters. From our side, it is essential to support at least PRS resource bandwidth, transmission periodicity, and PRS resource repetition factors as these highly affect the accuracy performance. If the current allocated PRS BW is not enough to meet the accuracy requirement, the UE needs to request additional bandwidth. Similarly, the UE may need more repetitions of PRS resources to ensure measurement accuracy. In addition, we suggest adding beam direction information to the list. The UE can request its preferred beam which towards a LoS direction.The benefit of muting pattern request is questionable. The muting pattern is up to network operation depending on the deployment. The network is difficult to satisfy a specific muting pattern of each UE’s request.  |

### Round #2

It seems there is some divergence among companies in terms of parameters that needs to be indicated for UE/LMF initiated on-demand DL PRS request. Given that it is the first time the topic is discussed, companies are invited to express views on parameters that are common for both request types and provide brief motivation. In order to facilitate more focused discussion let’s use the list of parameters in proposal below as a starting point and agree on initial agreeable set of parameters. The plan is to continue discussion on remaining set of parameters at the next meeting.

**Proposal 5.2-2**

* + NR supports pre-configuration of multiple DL PRS configurations to UE
		- FFS : contents of pre-configurations, procedure for on-demand DL PRS request
	+ At least the following set of parameters is signaled in both 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 minimal set of parameters for on-demand DL-PRS request:

|  |  |
| --- | --- |
| Company Name | Comments |
| vivo | During 1st round discussion for 5.1.1, there’s a sub-bullet* + - UE can indicate its preferred DL PRS configuration ID as a part of UE initiated on-demand DL PRS request

which states that UE can initiate on-demand request. However, that is not reflected in current 1st bullet and its sub-bullet. On the 2nd bullet, we don’t think all the listed parameters always need to be signaled in both UE- and LMF- initiated on-demand DL PRS request. So we suggest the following wording revision.* + NR supports pre-configuration of multiple DL PRS configurations to UE for both UE- and LMF- initiated on-demand DL PRS
		- FFS : contents of pre-configurations, procedure for on-demand DL PRS request
	+ Consider at least the following set of parameters to be signaled for both 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
 |
| Qualcomm | We are OK to change it to “consider” the 2nd bullet, but there needs to be a definite agreement that at least one or more paramteres can be signaled. Also, in the list of potential parameters we would like the following be considered:* Number of TRPs
* Number of PRS resources per PRS resource set
* Number frequency layers
* Beam directions

Therefore, we make the following proposal: *NR supports pre-configuration of multiple DL PRS configurations to UE for both UE- and LMF- initiated on-demand DL PRS** *FFS : contents of pre-configurations, procedure for on-demand DL PRS request*

*Support signaling one or more parameters for both UE- and LMF- initiated on-demand DL PRS request. Consider at least the following* 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*
10. *Number of TRPs*
11. *Number of PRS resources per PRS resource set*
12. *Number frequency layers*
13. *Beam directions*

*FFS additional parameters indicated for UE and/or LMF initiated on-demand DL PRS request* |
| Nokia/NSB | For the first bullet, we need to check if the preconfiguration feature was already agreed. The meaning of the “multiple DL PRS configuran” needs to be clarified. Is it mean multiple “NR-DL-PRS-AssistanceData-r16”?For the second bullet, we suggest adding “Beam direction information” to the list. The UE can request its preferred beam which towards a LoS direction. According to UE’s on-demand request, network can provide more bandwidth or time resources, but the network cannot satisfy the muting pattern according to the each UE’s request. Multiple UE might request different muting pattern. We suggest to remove the muting pattern in the list. |
| InterDigital | We are ok with the proposal suggested by vivo. |
| ZTE | For the first bullet, we prefer to replace ‘support’ by ‘consider’ since this may be also discussed in RAN2 because this signalling structure may belong to RAN2’s expertise. It is better to wait for RAN2’s outcome for at least one meeting.For the second bullet, we also prefer to consider instead of support the candidates. Moreover, we think one short or aperiodic on-demand PRS is beneficial for latency/overhead reduction. So we think * + NR ~~supports~~considers pre-configuration of multiple DL PRS configurations to UE
		- FFS : contents of pre-configurations, procedure for on-demand DL PRS request which may depend on RAN2’s outcome
	+ At least the following set of parameters is signaled in both UE- and LMF- initiated on-demand DL PRS request
	+ Consider at least the following set of parameters to be signaled for both 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 or the transmission time of aperiodic PRS ~~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
 |
| Huawei, HiSilicon | We think the first bullets needs RAN2 to design.There could be the case that that* Alt.1 Each configuration corresponds to the full set of PRS configuration, as Nokia mentioned multiple “NR-DL-PRS-AssistanceData” (I think the configuration numbers will blow)
* Alt.2 A single virtual configuration that simply lists the fields within the current IE structure that can take multiple values.

We woud like to note that some parameters that does not exist in the current PRS configuration may be added for on-demand PRS, e.g. number of transmissions if LMF-based on-demand PRS transmission triggers PRS transmission within a duration for a given periodicity, UE initiated TRP/PRS resource set priority (sequence sorting), LMF initiated boresight direction for a refined DL-AoD.So currently, we think we are only ready to accept the second bullet suggested by QC. This can be considered as compromise from our side, because we do not think some parameters are valid, e.g. repetition factor, muting pattern, number of symbols per resource (which changes comb size perhaps). In addition, we think the parameters can be demanded will be different for UE-initiated and LMF-initiated cases.*Support signaling one or more parameters for both UE- and LMF- initiated on-demand DL PRS request. Consider at least the following* 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*
10. *Number of TRPs*
11. *Number of PRS resources per PRS resource set*
12. *Number frequency layers*
13. *Beam directions*

*FFS additional parameters indicated for UE and/or LMF initiated on-demand DL PRS request* |
| CMCC | For the 1st bulet, fine with the version revised by ZTE, and for the 2nd bullet, fine with the one provided by QC. |
| LG | We support with 1st bulet in ZTE’s revision. Regardomg detils of parameter, we agree with HW’s revision. |
| vivo 2 | In generally, we are okay with the version revised by QC and propose to add some informations as following*NR supports pre-configuration of multiple DL PRS configurations to UE for both UE- and LMF- initiated on-demand DL PRS** *FFS : contents of pre-configurations, procedure for on-demand DL PRS request*

*Support signaling one or more parameters for both UE- and LMF- initiated on-demand DL PRS request. Consider at least the following* 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*
10. *Number of TRPs*
11. *Number of PRS resources per PRS resource set*
12. *Number of resource set per TRP*
13. *Number frequency layers or frequency layer indicator*
14. *Beam directions*
15. *Combsize, start PRB, Point A of DL PRS*
16. *ON/OFF indicator*

*FFS additional parameters indicated for UE and/or LMF initiated on-demand DL PRS request* |
| Ericsson | We think it is too early to decide already to support pre-configurations. This should be up to RAN2, and RAN1 can work the details as to what the pre-configuration can contain if it is agreed. We understand that RAN2 is also having a discussion regarding on-demand mechanisms and will send an LS regarding this as they are the leading group for this issue.  |
| CATT | Share the similar view as Ericsson.  |
|  |  |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
| ZTE | Alt.2. Out of scope for on-demand PRS. |
| CMCC | OK with Alt. 1, and we believe that reporting of UE/gNB measurement based on the periodic DL PRS should also be supported. |
| InterDigital | As we discussed in our contribution, how to report measurements for on-demand PRS is an important issue since measurements of on-demand PRS may have higher priority than the non-on-demand PRS. Whether on-demand measurement reports can be combined with non-on-demand PRS measurement reports should be discussed. Thus, we make the following proposal.Proposal : Further study measurement reporting for on-demand PRS and non-on-demand PRS (e.g., whether to separate measurement reports for on-demand PRS from measurement reports for non-on-demand PRS). |
| LG | Support.  |
| Sony  | Support |
| Nokia/NSB | Support FL’s proposal. If Alt 1 is supported then we should clarify that no additional configuration of those signals are made (i.e., whatever is available already can be leveraged).  |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
| ZTE | Similar to aperiodic and emi-persistent SRS, we’re OK to discuss aperiodic and semi-perstistent DL PRS.Physical-layer procedures to trigger the on-demand DL PRS configurations can be useful at least for DL PRS transmitted from TRPs associated with serving gNB. |
| CMCC | Support |
| InterDigital | Our view is that aperioid/semi-persistent PRS is configured according to the demand from the UE. Thus ,the topics can be discussed in on-demand AI. |
| vivo | To FL: According to the response, ON/OFF indication can be discussed as a part of on-demand DL parameters indication, but where is the discussion about ON/OFF indication and where can we discuss about it? |
| Sony | At this stage, we propose to keep the agreement simple: Support aperiodic and semi-persistent PRS for on-demand PRS. |
| Nokia/NSB | Agree with FL’s response but no need for an agreement. In our view, AP and SP PRS are not in scope of the WID. |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
| ZTE | This can be beneficial for both latency and on-demand PRS. |
| CMCC | We think that this can be handled under AI 8.5.4 regarding the MG enhancement. |
| InterDigital | We are ok to discuss this in the future but how to handle MG for on-demand PRS is an important issue. Since the MG here is related to on-demand PRS, our preference is to discuss the issue in the on-demand AI. |
| vivo | On-demand MG is beneficial for on-demand PRS. If UE is configured by on-demand PRS with a small periodicity for small latency requirement, but not require a new measurement gap and still measure and process PRS according to the previous measurement gap configuration, it fails to achieve the purpose of ‘on-demand’. We think it is more reasonable to discuss On-demand MG in this AI. |
|  |  |
|  |  |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
| CMCC | OK. |
| Nokia/NSB  | We are fine that this proposal is discussed in DL-AoD AI.  |
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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