**3GPP TSG RAN WG1 #106e R1-210zzzz**

**e-Meeting, August 16th – 27th, 2021**

**Source: Moderator (Intel Corporation)**

**Title: Feature Lead Summary#2 for E-mail Discussion [106-e-NR-ePos-02]**

**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 each section, we formulate tentative proposals for RAN WG1 discussion and decision and capture views provided by companies during RAN1 e-mail discussion [106-e-NR-ePos-02]:

|  |
| --- |
| [106-e-NR-ePos-02] Email discussion/approval on accuracy improvements for UL-AoA positioning solutions, with checkpoints for agreements on August 19, 24 and 27 – Alexey (Intel) |

Finally, in Section 4, we provide list of agreements made by RAN1 as an outcome of e-mail discussion [106-e-NR-ePos-02].

# Proposed Priority Order for Discussion

## Round #1

For initial discussion during the RAN1#106e, it is recommended to focus on Aspects 1 - Aspect 5.

* Aspect #1: Number of UL-AOA Values for the First Arrival Path
* Aspect #2: LCS-to-GCS Translation for UL-AOA Assistance
* Aspect #3: Reference UE for gNB/TRP Antenna Array Calibration
* Aspect #4: Antenna Reference Points
* Aspect #5: UL-AOA Report Enhancements

Companies are also encouraged to provide comments on other aspects as well.

1. UL-AOA Enhancements

## Aspect #1: Number of UL-AOA Values for the First Arrival Path

The following views were expressed by companies for the number of reported UL-AOA values for the first arrival path corresponding to the same timestamp:

* [ZTE, [2]]
	+ LMF indicates maximum number of UL-AOA values (pair of AOA & ZOA values) for the first arrival path corresponding to the same time stamp is up to 8.
* [vivo, [3]]
	+ The maximum number of UL-AOA values for the first arrival path that can be reported from gNB to LMF is {1, 2, 4}.
* [CATT, [6]]
	+ In Rel-17, support gNB to report up to 2 UL-AoAs values (pair of AoA & ZoA values, AoA values or ZoA values) per SRS resource for the first arrival path.
* [OPPO,[8]]
	+ The LMF does not indicate a maximum value. The TRP just report one or multiple measured UL-AoA values and the TRP reports the number of reported UL-AoA.
* [Intel, [12]]
	+ LMF indicates the maximum number of UL-AOAs values (pair of AOA & ZOA values) to be reported per SRS resource for the first arrival path corresponding to the same timestamp. The maximum number is selected from the set {1, 2, X1, X2}. X1 ≥ 4, X2 ≥ 8
		- FFS specific values for X1 and X2
* [InterDigital, [13]]
	+ Observation: The choice for the maximum number of UL-AOAs values (pair of AOA & ZOA values, AOA values or ZOA values) to be reported per SRS resource for the first arrival path depends on the target accuracy and latency required for processing.
* [NTT DOCOMO, [15]]
	+ Observation: Regarding the maximum number of UL-AoA values with the first arrival path, it may be better to consider that the uncertainty derived from reported multiple angles in addition to reporting overhead
* [Ericsson, [17]]
	+ [The maximum number of AoA values reported per SRS resource is selected from the set {1, 2, [X1], [X2]}](#_Toc76736523); [X1 = 4, X2 = 8](#_Toc76736524)

### Round #1 (Resolved)

Based on review of contributions the following is proposed to facilitate further discussion:

**Proposal 3.1-1**

* LMF indicates the maximum number of UL-AOAs values (pair of AOA & ZOA values) to be reported per SRS resource for the first arrival path corresponding to the same timestamp.
* The maximum number is selected from the set {1, 2, 4, X}
	+ FFS value of X

Comments from companies:

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| --- | --- |
| Company Name | Comments |
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## Aspect #2: LCS-to-GCS Translation for UL-AOA Assistance

The following agreement was made for UL-AOA assistance information signaling

|  |
| --- |
| Agreement:* Both GCS and LCS are supported for UL AoA/ZoA assistance information indication.
* Note: Existing signaling can be used for obtaining LCS to GCS translation information
 |

The following additional views were expressed for this aspect:

* [Huawei, [1]]
	+ Support TRP to provide the LCS-GCS translation to LMF via TRP information exchange.
		- Reasoning: for an RP that does not support PRS transmission, there is no way for LMF to collect the orientation in advance.

### Round #1 (Resolved)

Based on review of contributions, the following initial proposal is made to facilitate further discussion:

**Proposal 3.2-1**

* To support indication of UL AoA/ZoA assistance information in LCS, the LCS to GCS translation information is provided by gNB to LMF
	+ Signaling details up to RAN3

Comments from companies:

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| Company Name | Comments |
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## Aspect #3: Reference UE for gNB/TRP Antenna Array Calibration

The concept of (positioning reference unit) PRU was discussed by RAN1 in the context of UE/gNB Rx/Tx timing delays mitigation. The similar principle can be used for antenna calibrations.

The possibility to use reference UE/PRU to facilitate precise UL-AOA measurements through TRP antenna-element wise calibration was discussed by:

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

### Round #1

Based on review of contributions the following is proposed to facilitate further discussion:

**Proposal 3.3-1**

* LMF signaling of the expected angle of the positioning reference unit (PRU) to gNB/TRPs is supported

Comments from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | In geeral, we are fine with the proposal. However, assume there is no privacy issue for the PRU, it might be more efficient or the LMF to send the coordinates of the PRU to a gNB. In this way, the LMF does not need to calculate the expected angle of the positioning reference unit (PRU) for each TRP to the gNB. |
| Intel  | Support  |
| LG | We are frankly open to discuss the concept of PRU. However, as we all know, even though we spend some time supporting it, we didn’t reach a consensus in the last meeting and the LS related to PRU is finally endorsed. In this respect, we think that its too early to discuss specific issues like the proposal. And then, we need to discuss all other things that have been already infroduced from many other companies after waiting the response from RAN2/RAN3/SA2.  |
| vivo | We think it is to early to discuss this proposal, since the PRU is not definitely introduced. |
| Huawei, HiSilicon | Support. We understand the difficulty of PRU is on whether and how PRU are standardized, instead of whether and how PRUs are deployed. In case PRU is deployed (with or without standardized method), LMF should be able to send the expected angle of the PRU in a normal UL AoA measurement procedure to assist TRP antenna element-wise calibration. |
| Sony | We suggest to discuss this topic once the usage of PRU is supported. |
| Ericsson | Not needed unless a PRU is specified. In the last LS, the reference unit was a UE.  |
| CEWiT | Support |

### Round #2

Given that UL-AOA assistance information was agreed for UEs and reference UE was considered as a main candidate for PRU, it seems signaling can be automatically applicable to reference UE. Based on review of response the following is proposed to facilitate further discussion:

**Proposal 3.3-2**

* Conclude in chair notes:
	+ LMF signaling on UL-AOA assistance information is applicable to positioning reference unit (PRU), if some of the Rel-16 positioning functionalities of UE are agreed by RAN2 as a part of ongoing discussion on PRU

Comments from companies:

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| --- | --- |
| Company Name | Comments |
| CATT | Support |
| Fraunhofer | Support. And suggest zo replace “if some …” by if the “if the required Rel-16 positioning UE functionalities for UL-AOA are agreed …” |
| Qualcomm | Even though it’s a bit obvious for us this proposal (as any other AD information), I can see the procedural argument that we should wait whether eventually the PRUs are going to be supported.  |
| vivo | We are slightly inclined to discuss after PRU support. But we would like to confirm whether UL-AOA assistance information is the expected value and uncertainty range(or confidence level?). If it is expected value and uncertainty range, we prefer adding ”(expected value and uncertainty range)” in UL-AOA assistance information.In addition, whether the information is only used for the UL-AOA positioning method? |
| CEWiT | Support. The proposal can be extended to other uplink methods also. |
| LG | Support. |
| Nokia/NSB | We are generally fine with this proposal and also okay to wait until PRU is supported. If the reference device is a type of UE and if it is supported, it seems obvious that LMF provides them AD information. |
| OPPO | Do not support.First of all, we suggest to at least delay the discussion on this one until the discussion in RAN2 is concluded. We do not dicuss based on some “If”.Secondly, why AoA assistance information is needed for a PRU? If supported, PRU is supposed to be a Point with known location and the gNB use that to refine the AoA estimation. But this proposal propose the LMF to provide “expectd AoA”. |
| ZTE | This proposal is a bit confusing, we think the UL-AOA assistance information is sent from LMF to gNB/TRP. The proposal seems like the the UL-AOA assistance information is sent from LMF to UE. |
| Huawei, HiSilicon | Support.To OPPO: even if PRU is not specified in RAN2/RAN3/SA2, and leave it up to implementation, the proposal is still valid, that LMF could send the expected AoA of a PRU to a gNB.To ZTE: I think the majority understading of the proposal should be * + LMF signaling on UL-AOA assistance information (to a TRP of a normal UE) is applicable to (UL-AoA assistance information to a TRP of a) positioning reference unit (PRU), if some of the Rel-16 positioning functionalities of UE are agreed by RAN2 as a part of ongoing discussion on PRU
 |
| Ericsson | We do not see the impact on specifications, given that assistance data is already sent to gNB for a UE. Unless there is specific PRU-only assistance data sent to the gNB by the LMF, we do not see the need for this.  |

## Aspect #4: Antenna Reference Points

In [ZTE, [2]], 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.

The following views were expressed with respect to ARP and UL-AOA

* [ZTE, [2]]
	+ Rel-17 should support reporting UL-AOA measurement results being associated with ARP (Antenna Reference Point) information and
		- FFS: whether above enhancement can be also applicable to UL-RTOA, gNB Rx-Tx time difference and UL SRS-RSRP
* [Fraunhofer, [16]]
	+ For UL-AoA support TRP UL-measurements reporting of associated beam-specific ARP (Antenna Reference Point) information.

### Round #1

Based on review of contributions the following is proposed to facilitate further discussion:

**Proposal 3.4-1**

* Association of UL-AOA measurement results with ARP (Antenna Reference Point) ID information is supported

Comments from companies:

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| --- | --- |
| Company Name | Comments |
| CATT | Support |
| ZTE | Support |
| LG | We agree that the ARP information is currently provided through the LPP message. But, UE doesn’t report which ARP is used for measurement results. We think it is up to the implementation. Likewise, we are not sure why gNB needs to report measurement results accompanied by ARP information. we think it is also up to gNB because gNB accumulates measurement results from each ARP and derives one measurement instance from all of the results. we think that we need to clear the motivation of the proposal. |
| vivo | We have the same concern as Nokia, and we wonder about the benefits of introducing ARP for AoA positioning. Firstly, different panels can be seen as different TRPs as in the previous discussion.Secondly, for one panel, restrict ARP as partial antenna elements in horizontal/vertical direction is weird since the accuracy of AoA degrades with the decrease of using antenna elements number.Lastly, if a row of antennas can be seen as an ARP shown in the following figure, we wonder there is any difference in positioning calculation between the association of UL-AOA measurement results with ARP or not. That is, it may meaningless for LMF to know which ARP measures AOA since the (x,y) is the same for different ARP and UE 2D location calculation is independent of the vertical location of ARP (based on the formal: $AOA=\frac{x-x1}{y-y1}$).  Therefore, we propose to evaluate the benefits firstly. |
| Huawei, HiSilicon | Why do we need to report ARP ID? Is there any existing mapping between ID and location for the RP?We do not disagree with the intention, but the straightforward way is report the delta location of ARP with respect the TRP location. |
| ZTE2 | In the existing Rel-16 spec, different ARP can be configured for different PRS resources. The use case could be multiple panel TRPs, or distributed antennas. That is, different PRS resource may correspond to different locations. When LMF computes UE locations, it should consider ARP information of each PRS resources. For UL, we think the same feature should be supported in Rel-17 as TRPs may also use different panels (corresponds to different ARP) to receive SRS. This kind of design allows more flexibility for TRP to switch ON or OFF its APRs (or pannels) to receive UL SRSTo address Huawei’s concern, we suggest the following wording* Association of UL-AOA measurement results with ARP (Antenna Reference Point) ~~ID~~ information is supported

FFS: how to report ARP information (e.g. geometrical coordinate with respect to TRP location)@vivo we think the typical use case of ARP is the same as DL. Each ARP corresponds to one gNB panel rather than partial antenna elements in one panel. Another use case can be near-field AoA measurement as described in section 3.6.1. Furthermore, gNB may have more flexibility to switch ON or OFF its pannels to receive UL SRS, then gNB has to report its ARP location of the measured UL-AOA.@LG The reason why UE doesn’t need to report ARP information is because of that one DL PRS resource can only be associated with one ARP. Then if UE reports DL PRS resource ID, LMF will know the measurement result belongs to which ARP. However, currently this mechanism is not supported for UL. When LMF computes the UE location, it should consider the coordinate of receiver sides. Even for the same TRP, multiple panels may have different coordinates. Furthermore, gNB may have more flexibility to switch ON or OFF its pannels to receive UL SRS, then gNB has to report its ARP location of the measured UL-AOA. |
| Nokia/NSB  | We first would like to clarify what is ARP ID and need to separately discuss TRP and RP. In case of TRP, providing RX beam information via PRS resource(s) with UL measurement is a possible option to provide LMF with ARP information.  |
|  Ericsson | Do not support. This could be resolve by implementation at the gNB. For example the gNB could be configured as 2 TRPs if needed.  |
|  |  |

### Round #2

Given different DL PRS resource may correspond to different locations, it seems fair to consider this aspect more carefully. Based on review of responses, it is noticed that there is no common view:

* ARP solution is enabled for DL positioning but is not supported for UL positioning
* Aspect can be resolved by association of different RPs to different ARPs (i.e., implementation issue)

**Proposal 3.4-2**

* Select among the following alternatives:
	+ Alt.1:
		- Association of UL-AOA measurement results with ARP (Antenna Reference Point) information is supported
			* FFS for UL-TDOA, Multi-RTT
	+ Alt.2:
		- Explicit association of UL-AOA measurement results with ARP (Antenna Reference Point) information is not supported.
	+ Alt.3:
		- Conclude on whether association of UL-AOA, [UL-TDOA, Multi-RTT] measurement results with ARP (Antenna Reference Point) information is supported at RAN1#106bis-e

Comments from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | Support Alt.1. Alt.3 is also acceptable to us. |
| Fraunhofer | Support Alt.1For joint angle and timing estimation the LMF will require ARP association with the UL measurements (should be supported for UL-TDOA anf multi-RTT measurements as well). |
| vivo | Alt.2 is preferred  |
| LG | We are fine with the proposal at this time. We prefer to discuss it in the next meeting. |
| Nokia/NSB | In case the ARP can be associated with partial antenna elements, it could be helpful to address the near-field problem. We are fine with Alt.1 if a single ARP can be associated with a group of antenna elements. |
| OPPO | Alt.2 is preferred. We can be ok with Alt3 too. |
| ZTE | Support Alt.1. If we cannot get consensus, we’re fine with Alt.3.We want to emphasize that the TRP location information is provided by TRP INFORMATION RESPONSE before measurement request from LMF. It’s reasonable that gNB/TRP may change its antenna status( e.g. switch on and off some of antennas) during the positioning procedure, which cannot inform LMF dynamically.  |
| Huawei, HiSilicon | We suggest to clarify difference between multiple ARPs within a TRP and multiple TRPs.Alt.3 would be OK for now. |
| Ericsson | As mentioned in our previous response we see this as something implementation or deployment can resolve. OK to discuss further next meeting (alt3).  |
| Qualcomm | We are OK with Alt. 1 |

## Aspect #5: UL-AOA Report Enhancements

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

* [vivo, [3]]
	+ For UL-AoA positioning, there is no need to report RTOA or Rx-Tx Time Difference.
	+ Before we discuss about reporting of RSRP of first path
		- The definition of RSRP should be clarified.
		- Consult RAN4 to confirm the feasibility of measuring path-RSRP.
* [Sony, [4]]
	+ Support measurement quality indication (e.g., statistical property / standard deviation of AoA) of multiple AoA/ZoA measurements in UL-AoA measurement report from gNB to LMF.
	+ Support SRS resource ID information of the associated reported AoA / SRS-RSRP measurement in UL-AoA measurement report from gNB to LMF.
* [CATT, [6]]
	+ In Rel-17, support gNB to report one UL-AoAs value (pair of AoA & ZoA values, AoA values or ZoA values) per SRS resource per additional arrival path.
* [OPPO, [8]]
	+ TRP reports the UL AoA measurement, SRS-RSRP measurement and UL RTOA measurement of one same SRS resource and the TRP can report those measurement of multiple SRS resources
	+ The reported UL AoA, UL RTOA and SRS-RSRP can be measured from the first path or other path of one SRS resource.
* [Qualcomm, [9]]
	+ Support a gNB to report multiple tuples (UL-AoA, UL-RSRP, RTOA/gNB Rx-Tx) within a single report, such that
		- The UL-RSRP corresponds to a relative RSRP associated to the reported path in the angle/delay domain.
		- The RTOA/gNB-Rx-Tx corresponds to the delay of the associated reported path in the angle/delay domain
		- The UL-AoA corresponds to the received angle (potentially 2-dimensional) of the associated reported path in the angle/delay domain
	+ Support at least [8] (UL-AoA, UL-RSRP, RTOA/gNB Rx-Tx) tuples that can be sent in a single report
* [CMCC, [10]]
	+ For UL-AOA positioning, the benefit and necessity on supporting of path-specific RSRP and UL-RTOA measurements based on SRS (for positioning, MIMO) should be further clarified.
	+ For UL-AOA positioning, support of path-specific UL-RTOA measurements reporting based on SRS (for positioning, MIMO) can be achieve by hybrid UL-AoA and UL-TDoA.
* [LGE, [11]]
	+ If the values of AoA/ZoA are reported by resource, followings should be considered:
		- Other elements in single measurement report such as SRS-RSRP, RTOA, and Rx-Tx time difference also need to be reported by resource.
		- Additional information such as SRS resource ID, SRS resource set ID also needs to be included in the measurement report.
* [Apple, [14]]
	+ Support UL-SRS-RSRP (and/or UL-RTOA) measurement within a configured time window wherein the power of paths out of the window, if any, does not contribute in SRS-RSRP (or UL-RTOA) measurements.
		- Alternatively, or additionally, for UL-AoA technique, support UL-SRS-RSRP (and/or UL-RTOA) for the first arrival path only that is measured within a configured time window.
* [Ericsson, [17]]
	+ [The gNB can report the UL SRS RSRP path power together with first path AoA, define as the peak power measured for a given time t upon reception of a given SRS.](#_Toc76736522)
* [CEWiT, [18]]
	+ For UL-AoA positioning, reporting of path-specific RSRP, path-RTOA and path-AoA measurements for first arrival path and additional paths from gNB to LMF should be supported.

### Round #1

In this AI and section, only aspects related to the first arrival path are discussed. Additional paths are expected to be discussed under AI 8.5.5.

Based on review of contributions the following is proposed to facilitate further discussion:

**Proposal 3.5-1**

* First arrival path RSRP, UL-RTOA and multiple UL-AOAs measurements per SRS resource for positioning and SRS resource for MIMO are supported
	+ The set of above measurements can be provided in a single gNB report to LMF

Comments from companies:

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| --- | --- |
| Company Name | Comments |
| CATT | We are supportive to have one single gNB report to include RSRP, UL-RTOA and UL-AOAs measurements per SRS resource. In the proposal, the singular is used for RSRP and UL-RTOA but plural for UL-AOAs measurements, then our understanding is the proposal only proposes one RSRP, one UL-RTOA, and multiple UL-AOAs. With the understanding, suggest making the following changes:* Reporting of one path RSRP, one UL-RTOA and multiple UL-AOAs measurements for the first path per SRS resource for positioning and/or per SRS resource for MIMO in a single gNB report to LMF is supported
 |
| ZTE | UL-RTOA and UL-AOA have already been supported in Rel-17. Regarding path RSRP, we think we should wait for the conclusion from DL-AOD agenda. If it’s agreed, similar definition can be adopted. |
| Intel  | Support reporting for the first arrival path. |
| LG | We are fine with CATT’s version. We have two concerns about the proposal. The first thing is that we should discuss the current ambiguity problem as we mentioned in our contribution. In fact, if multiple measurement results from multiple SRS resources within a single time stamp are provided for LMF, LMF can not distinguish which resource is used. So, we think SRS resource ID, SRS resource set ID should also be included in the measurement report. So, considering it, those should also be included in the proposal.The second thing is about “SRS resource for MIMO”, could anyone give us the description in the current specification regarding that SRS for MIMO can be used for AoA measurements. If it is supported currently, we are okay. |
| Vivo | We would like to confirm whether the RSRP corresponds to a UL-AOAs measurement and if it is, whether the power of multiple UL-AOAs measurements is the same so that only one RSRP is needed for multiple UL-AOAs measurements. |
| Huawei, HiSilicon | We think the reporting of SRS resource ID should be trivial since we already agreed in the TEG session that gNB should be able to report the SRS resource ID associated with RTOA measurement. Note that RAN3 NRPPa does not differentiate positioning methods, and thus what can be useful for UL-TDOA could automatically be used for UL-AoA.To LGE, spec does not restrict use of MIMO-SRS for UL-AoA, which is otherwise for Multi-RTT. |
| Nokia/NSB  | We are generally okay. In NRPPa spec, MIMO SRS can be found in section 9.2.28/9.2.29 of 38.455. |
| SONY | We have a similar concern as vivo’s above. Furthermore, the motivation of having multiple UL-AoA measurements is unclear. |
| Ericsson | Support. Regarding path RSRP, we think that each measurement could have its own path RSRP, particularly if the measurement are performed with different Rx beams. Should the proposal say “for UL-AOA” ? |
| CEWiT | We support reporting of path-AoA, path-RTOA and path-RSRP atleast for the first arrival path. |
|  |  |

### Round #2

Based on review of responses it seems revision of the proposal can be acceptable to majority of companies. Therefore, the following is proposed to facilitate further discussion:

**Proposal 3.5-2**

* Reporting of one RSRP, one UL-RTOA and multiple UL-AOAs measurements for the first arrival path per SRS resource for positioning and/or per SRS resource for MIMO in a single gNB report to LMF is supported
	+ The above measurements are associated with SRS resource ID which is also reported to LMF

Comments from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | Support |
| Qualcomm | OK (under the common understanding that it is transparent to the UE) |
| Apple | OK, once it is mentioned that “The use of SRS for MIMO resource is transparent to the UE”, as mentioned by QC |
| vivo | Could the proponent answer why one RSRP corresponds to multiple UL-AOAs measurements, whether the power of multiple UL-AOAs measurements is the same so that only one RSRP is needed for multiple UL-AOAs measurements? In the previous Huawei Tdoc, the power for multiple UL-AOAs is different, but in Intel Tdoc, the power is the same. So we are confused about this issue.Radiation pattern with antenna elements separation equals to two wavelength |
| CEWiT | Support. |
| LG | Support |
| Nokia/NSB | Support |
| OPPO | Support but suggest to make it clear that there is no extra specification support for SRS for MIMO. We did have such note is previous agreement. We prefer to include that again here to avoid confusion.**Proposal 3.5-2*** Reporting of one RSRP, one UL-RTOA and multiple UL-AOAs measurements for the first arrival path per SRS resource for positioning and/or per SRS resource for MIMO in a single gNB report to LMF is supported
	+ The above measurements are associated with SRS resource ID which is also reported to LMF
	+ Note: TRP measurement on SRS resource for MIMAtO is transparent to UE.
 |
| ZTE | We prefer to further study RSRP before we make any decision on definition of the path RSRP in DL-AOD agenda. At least the issue raised by vivo should be clarified. |
| Huawei, HiSilicon | Support.Clarify to vivo: In HW’s t-doc, we use the radiation pattern to show the angle ambiguity from Tx side, since it is obvious in term of sidelobes. On the receiver side, since we do not have any distance estimation between TRP and UE, TRP cannot estimate which lobe UE is located in based on the RSRP. TRP will receive SRS on multiple Rx ports, estimate the CIR on multiple Rx ports, extract the first path, estimate the power and phase change on the first path across multiple Rx ports. The phase change will convert to multiple AoAs, due to 2pi ambiguity.So it is technically correct that a single RSRP (total/path) could correspond to multiple AoAs. |
| Ericsson | support |
| Qualcomm2 | Need to update our views: the earliest path (RTOA) can be associated with multiple angles, each angle having each own RSRP potentially. When we get a Angle/TOA channel response, at each TOA, multiple angles may correspond to, and different angles will have different power. HW is brining up an issue that the reason of having this proposal is due to the ambiguity. OK that’s one topic, but even without angle ambiguity, at the earliest TOA, one could observe multiple angles, each one with each one power.  |

## Aspect #6: UL-AoA measurements in Near-field

The support of UL-AOA measurement in near-field was discussed by:

* [Nokia, [7]]
	+ TRP may need to determine a group of antennas which has almost the same incident angle within a certain margin to assume a single incident angle for AoA estimation. The number of antennas of a group might be different.
	+ RAN1 to study AoA measurement improvement, considering the case where a single planar wave assumption is not valid, based on the distance between the UE and the TRP, for the overall antenna elements within a reception antenna panel/array.

This aspect may be relevant to the discussion on association of UL-AOA meaasurmeents with ARP.

### Round #1

Based on review of contributions the following is proposed to facilitate further discussion:

**Proposal 3.6-1**

* Companies are invited to provide further comments on whether and which specification support may be needed to enhance UL-AOA measurements in near-field

Comments from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | Providing the expected location of the UE by the LMF to gNB could help gNB to resolve the issue. |
| ZTE | To our understanding, this is have similar spec impact as Aspect#4, i.e. different UL-AOA measurement results may be associated with different reference point. |
| LG | We have a similar view of CATT. Depending on the result of a discussion on PRU, we believe that the problem can be resolved. |
| vivo | Low priority |
| Huawei, HiSilicon | We acknowledge that Nokia brought up the issue for real deployment. However, we cannot see any spec impact to resolve this. |
| Nokia/NSB  | Support. The near-field issue discussion in our Tdoc[7] has not been discussed but it is highly related to AoA measurement performance especially for InF scenario since the UE is close to the TRP. We would like to suggest identifying potential solutions and specification impacts if a single planar wave assumption is not valid within an array antenna.  |
| SONY | The idea is interesting. However, we are not sure on the specification impact. |
| Ericsson | This can be handled outside of the specs.  |
| CEWiT | We support the study but not sure about the standardization impact. |

### Round #2

Based on review of responses the following is proposed to facilitate further discussion:

**Proposal 3.6-2**

* Continue discussion on potential specification impact to support near-field UL-AOA measurements

Comments from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | Support. Providing the expected location of the UE by the LMF to gNB could help gNB to resolve the issue. |
| Qualcomm | Not support |
| Apple | Not support |
| LG | Not support. Same with our comment proposal 3.6-1 |
| Nokia/NSB | Support, but we do not think it is necessary to make an agreement on this proposal. |
| OPPO | Not support. |
| Huawei, HiSilicon | Not clear what should do. |
| Ericsson | Do not support, but we agree that we can continue discussing this.  |

## Aspect #7: Additional Assistance Signaling

Additional assistance signaling for UL-AOA were proposed by:

* [Fraunhofer, [16]]
	+ For facilitating TRP UL-AoA measurements, support that the LMF indicates a DL-PRS resource for the expected AoA/ZoA and uncertainty range.
* [Sony, [4]]
	+ Support LMF to provide a time validity information associated with the expected AoA/ZoA range
* Note: The proposal provided in [Fraunhofer, [16]] was already discussed. There was no consensus to support this functionality

### Round #1

Based on review of contributions the following is proposed to facilitate further discussion:

**Proposal 3.7-1**

* Companies are invited to provide comments on a time validity information associated with the expected AoA/ZoA range

Comments from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | We assume LMF can provide the updates of the expected AoA/ZoA range in case the previous information is no longer valid. |
| ZTE | The same view with CATT. It’s up to LMF implementation. |
| LG | We have a question for clear understanding. Is the intention of providing time validity information to ensure how long the related assistance information can be used due to UE's mobility? If it is right, we think the proposal also cannot resolve the fundamental problem. For example, we worry how LMF expects the time validity information to be valid and we also think uncertainty is alredy supported to cover it. Even though we agree with the motivation, we think another improvements need to be considered. Likewise, If LMF provides UE the related information which is used for calculation of expected AoA/ZoA such as the pre-calculated(known) location of UE and related threshold, it can be example solution for the problem. |
| Nokia/NSB  | Okay for further study to identify problems and performance impact.  |
| SONY | In principle, LMF obtained the time validity in similar way as how the LMF obtained the AoA/ZoA range (e.g. LMF obtained from the history of UE positioning measurement/estimation reports). How LMF obtained the time validity is up to LMF implementation. Time validity is dominantly affected by the UE mobility.Without time validity information, there is a risk that gNB uses an out-dated assistance information which may lead to inaccurate/sub-optimal UE position measurement / estimation. |
| Ericsson | As CATT proposed, LMF could simply update the information.  |
|  |  |

### Round #2

Based on review of responses the following is proposed to facilitate further discussion:

**Proposal 3.7-2**

* Proponents are encouraged to continue discussion on benefit of the proposed solution vs LMF implementation based option with update of UL-AOA assistance information

Comments from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| vivo | Actually, we mentioned the same feature on the UE side. The main reason is we think the accurate expected AoA/ZoA range is one-shot information, and then UE can combine the previous measurement to track the signal just like track receiving timing.  |
| LG | Actually, we don’t need a proposal at this time. The proposal need to be discussed after checking benefits. |
| OPPO | It is hard to see the benefit to specific it considering LMF-implementatation method can totally solve the issue.  |
| ZTE | Not support. |
| Huawei, HiSilicon | We think it should be better up to network implementation. |
|  |  |
|  |  |

## Aspect #8: Beamforming and UL AOA Estimation

Beamforming related aspects in application to UL-AOA estimation were discussed by:

* In [Samsung, [5]],
	+ It is proposed to support differential beamforming technique for UL-AOA positioning methods.
* [Nokia, [7]]
	+ Study beam resolution control/recommendation by LMF for more accurate AoA measurement by beam interporlation based AoA estimation method based on RSRP measurements. - Request to gNB : beam resolution recommendation, number of RSRP measurement

### Round #1

Based on review of contributions the following is proposed to facilitate further discussion:

**Proposal 3.8-1**

* Companies are invited to provide comments on beam resolution control/recommendation by LMF to gNB and support of differential beamforming
	+ Note: proponents are encouraged to provide more details on specification impact

Comments from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | Whether to use differential beamforming for the reception of the UL-AoA seems up to gNB implemention without the impact on specification. |
| ZTE | Up to gNB implementation. |
| LG | We have a similar view with CATT. |
| Nokia/NSB  | Support. The Rx beam resolution and direction may affect AoA measurement performance.   |
| Ericsson | Same view as above.  |
|  |  |
|  |  |

### Round #2

Based on review of responses the following is proposed to facilitate further discussion:

**Proposal 3.8-2**

* No consensus on additional specification work on beam resolution control/recommendation by LMF to gNB and support of differential beamforming
	+ Note: proponents are encouraged to provide more details on specification impact to next meeting

Comments from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | Support the conclusion |
| Qualcomm | No need for a conclusion |
| vivo | Okay with the conclusion |
| LG | We have similar view with QC. |
| Nokia/NSB | Similar view with QC. |
| OPPO | Do not need a conclusion. |
| ZTE | No need for a conclusion. |

## Aspect #9: SRS for Positioning Power Control

The following views were expressed on power control enhancements for SRS for positioning

* [Samsung, [5]]
	+ 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.
* [OPPO, [8]]
	+ Enhance the uplink power control of SRS for positioning as follows:
		- Support closed-loop power control on SRS for positioning.
		- Support configuring power control parameter per SRS resource for positioning

### Round #1

Based on review of contributions the following is proposed to facilitate further discussion:

**Proposal 3.9-1**

* Companies are invited to provide further comments on power control enhancements for SRS for positioning

Comments from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | Closed-loop power control of SRS-Pos, especially for the neighboring cells, may not be simple task and is not in the scope of the WI in our understanding. |
| ZTE | Out of scope. |
| LG | Since we think power control is also an important issue to increase the accuracy, we also support it. |
| Nokia/NSB  | Our understanding is that this is out of scope of the WID.  |
| SONY | It is not within the scope of Rel-17 WID. |
|  |  |

### Round #2

Based on review of contributions the following is proposed to facilitate further discussion:

**Proposal 3.9-2**

* Conclude that aspect is out of WID scope

Comments from companies:

|  |  |
| --- | --- |
| Company Name | Comments |
| CATT | Support the conclusion |
| Qualcomm | No need for a conclusion |
| ZTE | Support the conclusion. We don’t need to treat this topic again in following meetings. |
| Ericsson | OK |
|  |  |
|  |  |
|  |  |

1. Conclusion

In this contribution, we provided review of the submitted contributions for NR Positioning UL-AOA enhancements and prepared set of proposals to facilitate further discussion/decision by RAN WG1 during the RAN1#106e meeting.

The following agreement and conclusion were made during the 1st GTW call on Aspect #1 and Aspect #2 respectively:

Agreement on Aspect #1

|  |
| --- |
| * The maximum number of UL-AOAs values (pair of AOA & ZOA values) to be reported per SRS resource for the first arrival path corresponding to the same timestamp is 8.
 |

Conclusion on Aspect # 2

|  |
| --- |
| * It is up to RAN3 to decide how to support indication of UL AoA/ZoA assistance information in LCS for LCS to GCS translation
 |

1. References
2. R1-2106450 Enhancement for UL AoA positioning Huawei, HiSilicon
3. R1-2106550 Accuracy improvement for UL-AoA positioning solutions ZTE
4. R1-2106596 Discussion on potential enhancements for UL-AoA method vivo
5. R1-2106810 Considerations on UL-AoA enhancements Sony
6. R1-2106889 Discussion on accuracy improvements for UL-AoA positioning solutions Samsung
7. R1-2106972 Discussion on enhancements for UL-AoA positioning method CATT
8. R1-2107058 Views on enhancing UL AoA Nokia, Nokia Shanghai Bell
9. R1-2107214 Enhancements for UL AoA Positioning OPPO
10. R1-2107346 Potential Enhancements on UL-AOA positioning Qualcomm Incorporated
11. R1-2107404 Discussion on UL-AoA enhancements CMCC
12. R1-2107543 Discussion on accuracy improvement for UL-AoA positioning LG Electronics
13. R1-2107591 Remaining Details of NR Positioning UL-AoA Enhancements Intel Corporation
14. R1-2107645 Discussion on enhancements for UL-AoA positioning solutions InterDigital, Inc.
15. R1-2107741 Positioning Accuracy enhancements for UL-AoA Apple
16. R1-2107859 Discussion on UL-AoA positioning enhancements NTT DOCOMO, INC.
17. R1-2108102 UL-AoA positioning enhancements Fraunhofer IIS, Fraunhofer HHI
18. R1-2108165 Enhancements of UL-AoA positioning solutions Ericsson
19. R1-2108176 Discussion on enhancements for UL AoA positioning CEWiT