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

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

**Source: Moderator (Intel Corporation)**

**Title: Feature Lead Summary#1 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.

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

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:

|  |  |
| --- | --- |
| Company Name | Comments |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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

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:

|  |  |
| --- | --- |
| Company Name | Comments |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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:

|  |  |
| --- | --- |
| Company Name | Comments |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 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 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

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 agreements were made by RAN1 during the RAN1#106e meeting on the topics discussed in this document:

References

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

UL AOA

Huawei (X1)

Observation 1: The phase error across antenna elements could be only calibrated by each TRP.

Note: The bearing error correction can be maintained by the LMF.

Proposal 1: Support LMF to send the expected angle of the reference device to gNB for TRP antenna-element wise calibration.

Proposal 2: Support TRP to provide the LCS-GCS translation to LMF via TRP information exchange.

ZTE (X2)

**Observation 1**: 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 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.

**Proposal 1**: In order to improve positioning accuracy, Rel-17 should support reporting UL-AOA measurement results being associated with ARP (Antenna Reference Point) information

FFS: whether above enhancement can be also applicable to UL-RTOA, gNB Rx-Tx time difference and UL SRS-RSRP

**Proposal 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 (X3)

O1

* For reporting of multiple values of UL-AOAs for the first arrival path, the maximum number of 2 or 4 is enough.

O2

* For UL-AoA positioning, there is no need to report RTOA or Rx-Tx Time Difference.

P1

* The maximum number of UL-AOA values for the first arrival path that can be reported from gNB to LMF is {1, 2, 4}.

P2

* 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 (X4)

Observation 1: The uAoA indicator can improve the UL-AoA positioning accuracy in any scenarios. The gain from the proposed method can up to 0.8 m in InF-DH case. Even in InF-SH FR2, the method can still obtain 68% gain over the legacy AoA.

Observation 2: The accuracy of the proposed method in InF-SH FR1,2 and InF-DH FR1 can fulfil the IIoT requirement (less than 0.2 m for 90% of the UE). In InF-DH FR2, the obtained accuracy for 90% of the UEs is 0.26m, in which it is almost meeting the accuracy requirement.

Proposal 1: Support LMF to provide a time validity information associated with the expected AoA/ZoA range.

Proposal 2: 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.

Proposal 3: Support SRS resource ID information of the associated reported AoA / SRS-RSRP measurement in UL-AoA measurement report from gNB to LMF.

Samsung (X5)

Observation 1: the normal UL-AOA methods may not provide good enough estimation accuracy as well as latency.

Observation 2: the differential beamforming technique is beneficial for improving UL-AOA method to better satisfy the positioning requirement.

Observation 3: the gNB scheduling could ensure the proper SRS-pos configuration in order to support reception based on differential beam techniques.

Observation 4: the power setting for the SRS-pos might be not appropriate for neighbouring cell measurement.

Proposal 1: Support differential beamforming technique for UL-AOA positioning methods.

Proposal 2: the power control enhancement for SRS-pos to improve UL-AOA based solution should be considered.

CATT(X6)

Proposal 1: 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.

Proposal 2: 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.

Nokia

Observation 1: LoS path estimation is required for accurate AoA estimation in most cases.

Observation 2: UL signal input angle from a target UE is not always located at the peak angle of a beam lobe, and it can be an in-between angle of two discrete beam directions.

Observation 3: A gNB serves multiple UEs, so AoA estimation also needs to be designed for multiple UE positioning targets.

Observation 4: The far-field assumption for a simple planar wave across overall antennas is not always valid according to the distance between UE and TRP.

Proposal 1: 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.

Observation 5: UL RSRP accuracy function is shown as a function of beamforming codebook selection and steering angle.

TX and RX steering vectors must be aligned toward a steering direction.

Configuration of a beamforming codebook affects accuracy of measured UL-RSRP values.

Proposal 2: 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

OPPO (X8)

Proposal 1: For linear antenna array, in addition to the ZoA relative to the z-axis, the TRP also reports an estimated range of AoA.

Observation 1: SRS transmission with multiple paths would impair the performance of UL AoA method.

Observation 2: Implementation-based solution at TRP can mitigate the impact of multi path: the TRP can first detect the first arrival path and then estimate the UL AoA only from the first arrival.

Observation 3: When multiple SRS resources for positioning from different Tx beams are received, TRP can use the SRS resource with smallest UL RTOA to measure UL AoA based on implementation.

Observation 4: More information can be transferred to LMF for facilitate the improvement of UL-AoA positioning, including multiple angle of arrivals estimation, associated UL-RTOA and associated SRS-RSRP

Proposal 2: Support that the 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

Proposal 3: The reported UL AoA, UL RTOA and SRS-RSRP can be measured from the first path or other path of one SRS resource.

Proposal 4: Regarding the number of reported UL-AoA values:

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.

Observation 5: According the current design, same path loss is used on all the SRS resources for positioning targeting to different TRP and the Tx power determined for SRS for positioning might cause the following two consequences:

The power is not sufficient for the SRS to reach the target TRP.

The power might be too large for the nearby TRP.

Proposal 5: 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

Qualcomm (X9)

Proposal 1: 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 (X10)

Observation 1: 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.

Proposal 1: 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)

Observation #1:

For UL AOA measurement from gNB to LMF, if the values of AoA/ZoA are reported by resource, LMF cannot distinguish which SRS resource is used for measurement since the unit (e.g. granularity) of the time stamp is slot.

Proposal #1:

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.

Intel (X12)

Proposal 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, X1, X2}

X1 ≥ 4, X2 ≥ 8

FFS specific values for X1 and X2

InterDigital (X13)

Observation 1: 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.

Apple (X14)

**Proposal 1**: For UL-AoA technique, 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.

DOCOMO (X15)

Observation 1:

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

Fraunhofer (X16)

Proposal 1: For facilitating TRP UL-AoA measurements, support that the LMF indicates a DL-PRS resource for the expected AoA/ZoA and uncertainty range.

Proposal 2: For UL-AoA support TRP UL-measurements reporting of associated beam-specific ARP (Antenna Reference Point) information.

Ericsson (X17)

[Proposal 1 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)

[Proposal 2 The maximum number of AoA values reported per SRS resource is selected from the set {1, 2, [X1], [X2]}](#_Toc76736523)

[a. X1 = 4, X2 = 8](#_Toc76736524)

CEWiT (X18)

**Observation: Multipath measurements help in improving the accuracy of positioning based on NLOS mitigation and multipath positioning.**

**Proposal:** **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.**