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

**e-Meeting, October 11th – 19th, 2021**

**Source: Moderator (Intel Corporation)**

**Title: Feature Lead Summary#1 for E-mail Discussion [106bis-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]-[17]. In each section, we formulate tentative proposals for RAN WG1 discussion and decision, and capture views provided by companies during RAN1 e-mail discussion [106bis-e-NR-ePos-02]:

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| [106bis-e-NR-ePos-02] Email discussion/approval on accuracy improvements for UL-AoA positioning solutions, with checkpoints for agreements on October 14 and 19 – Alexey (Intel) |

# Proposed Priority Order for Discussion

## Round #1

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

* Aspect #1: UL-AOA Report Enhancements
* Aspect #2: Definition of Path Specific UL SRS-RSRP Measurements
* Aspect #3: ARP Association with UL Measurements

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

UL-AOA Enhancements

## Aspect #1: UL-AOA Report Enhancements

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

* [vivo, [3]]
  + Do not support reporting of RSRP for the first arrival path.
* [OPPO, [4]]
  + In addition to the UL-RTOA or gNB Rx-Tx time difference and N≥1 UL-AoA measurements for the first arrival path per SRS resource, the gNB shall also report N RSRP measurement and each RSRP measurement correspond to one reported UL-AoA measurement.
  + For linear antenna array, in addition to the ZoA relative to the z-axis, the TRP also reports an estimated range of AoA.
* [CATT, [5]]
  + Support reporting any of the combinations of {multiple UL-AoAs measurements, one UL SRS-RSRP, one UL RTOA, one gNB Rx-Tx Time Difference} for the first arrival path per positioning SRS resource in a single gNB report to LMF.
    - The above measurements are associated with positioning SRS resource ID that is also reported to LMF
  + Support reporting any of the combinations of {multiple UL-AoAs measurements, one UL SRS-RSRP, one UL RTOA} for the first arrival path per MIMO SRS resource in a single gNB report to LMF.
    - The above measurements are associated with MIMO SRS resource ID that is also reported to LMF
* [Sony, [10]]
  + Support SRS resource ID information of the associated reported AoA/SRS-RSRP measurement in UL-AoA measurement report from gNB to LMF
  + Support measurement of a AoA statistical property (e.g., statistical property / standard deviation of multiple AoA/ZoA measurements in UL-AoA measurement) as a new quality indicator in the quality matrixes, reported from gNB to LMF
* [Intel, [8]]
  + Support reporting of one UL-RTOA, one RSRP and multiple UL-AOA measurements for the first arrival path per SRS resource for positioning in a single gNB report to the LMF
    - The above measurements are associated with the SRS resource ID which is also reported to LMF
  + Support reporting of one gNB Rx-Tx time difference, one RSRP and multiple UL-AOA measurements for the first arrival path per SRS resource for positioning in a single gNB report to the LMF
    - The above measurements are associated with the SRS resource ID which is also reported to LMF
* [NTT DOCOMO, [9]]
  + Regarding single reporting of multiple measurements with first arrival path, it may be better to consider reporting of both RSRP and multiple angle information
* [Apple, [12]]
  + For UL-AOA positioning, when multiple positioning SRS resources are received, gNB shall report UL-AoA measurements associated to the first arrival path of two positioning SRS resources; the one with the largest SRS-RSRP and another one with the shortest UL-RTOA.
* [InterDigital, [14]]
  + RSRP per UL-AOA for the first arrival path can be reported by the gNB to the LMF
* [Qualcomm, [15]]
  + Support a gNB to report the path-RSRP power associated with (AoA, RTOA, Rx-Tx) measurements for the first (and additional) arrival paths.
* [CeWiT, [16]]
  + In some scenarios, reporting first arrival path power is important for better accuracy of the AoA estimation at LMF.
  + For UL-AoA positioning, reporting of path- RSRP along with path-RTOA and path-AoA measurements for first arrival path from gNB to LMF should be supported.
* [Ericsson, [17]]
  + Support SRS path RSRP reporting for the first path for UL AoA.
    - The path RSRP can be reported as a single measurement valid for all the AoA/ZoA pairs corresponding to the same timestamp in the measurement report
    - The path RSRP can also be reported for each AoA/ZoA pairs corresponding to the same timestamp in the measurement report
  + The gNB can report the UL SRS RSRP first path power together with first path AoA, defined as the CIR peak power measured at the time t0, where t0 is the time of arrival of the SRS resource on which the the measurement is performed. The time t0 can be derived by the LMF using the UL RTOA measurement and the location of the SRS symbol in the transmitted slot.

**Summary:**

Majority of companies support SRS-RSRP reporting for the first arrival path per SRS resource for positioning in addition to UL RTOA, gNB Rx-Tx time difference measurements and multiple UL-AoA values.

### Round #1

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

**Proposal 3.1-1**

* For the first arrival path measurements on SRS for positioning resource, adopt one or both alternatives
  + Alt.1: gNB can report to LMF the following set of measurements {one SRS-RSRP, multiple UL-AOAs (AoA/ZoA pairs), one UL-RTOA, one-gNB Rx-Tx time difference}
  + Alt.2: gNB can report to LMF the following set of measurements {multiple SRS-RSRP, multiple UL-AOAs (AoA/ZoA pairs), one UL-RTOA, one-gNB Rx-Tx time difference}
* For the first arrival path measurements on SRS for MIMO resource, adopt one or both alternatives
  + Alt.1: gNB can report to LMF the following set of measurements {one SRS-RSRP, multiple UL-AOAs (AoA/ZoA pairs), one UL-RTOA}
  + Alt.2: gNB can report to LMF the following set of measurements {multiple SRS-RSRP, multiple UL-AOAs (AoA/ZoA pairs), one UL-RTOA}
* All gNB measurements above are associated with SRS resource ID and timestamp, which are also reported to LMF

Comments from companies:

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## Aspect #2: Definition of Path Specific UL SRS-RSRP Measurement

The following views were expressed on definition of path specific UL SRS-RSRP measurement

* [Huawei, [1]]
  + Adopt the following definition of path UL SRS-RSRP measurement
    - Path UL SRS-RSRP of delay-D is the power (in [W]) of the linear average of the delay-D compensated channel frequency response of the resource elements that carry sounding reference signals. Path UL SRS-RSRP shall be measured over the configured resource elements within the considered measurement frequency bandwidth in the configured measurement time occasions.
  + For path UL SRS-RSRP measurement reporting, when receiver diversity is in use, at least consider additionally reporting the Rx branch set ID to identify whether different path RSRP measurements are associated with the same Rx branch set.
    - Spatial filtering based on the UL-AoA measurement on the Rx branches in the Rx branch set is optional.
* [Nokia, [6]]
  + The measured first-path SRS RSRP corresponds to the power of the channel impulse response, at the first path delay, over which the SRS is received.
    - Note: the first path delay is independent of sampling grid.
    - Note: the first path delay is the channel tap where gNB measures ToA for reporting of the RSRP of the first path
    - FFS: window/time-duration around the first path (e.g., size of 1 Ts) to calculate power

**Summary**

From FL perspective, the selection of the measurement definition depends on ongoing discussion for definition of path specific DL PRS RSRP measurements and should be aligned. It can be also derived based on modified Rel.16 UL SRS-RSRP definition as a starting point, e.g.:

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| **Definition** | UL SRS reference signal received power for the first arrival path (UL SRS-RSRPFAP) is defined as power of the channel impulse response at the first arrival path delay. UL SRS‑RSRPFAP shall be measured over the configured resource elements within the considered measurement frequency bandwidth in the configured measurement time occasions.  For frequency range 1, the reference point for the UL SRS-RSRPFAP shall be the antenna connector of the gNB. For frequency range 2, UL SRS-RSRPFAP shall be measured based on the combined signal from antenna elements corresponding to a given receiver branch. For frequency range 1 and 2, if receiver diversity is in use by the gNB, the reported UL SRS-RSRPFAP value shall not be lower than the corresponding UL SRS-RSRPFAP of any of the individual receiver branches. |

### Round #1

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

**Proposal 3.2-1**

* The first arrival path UL SRS-RSRP measurement is defined as the power of the channel impulse response, at the first path delay, over which the UL SRS resource is received
  + Path UL SRS-RSRP shall be measured over the configured resource elements within the considered measurement frequency bandwidth in the configured measurement time occasions
  + FFS considerations for receiver diversity

Comments from companies:

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## Aspect #3: ARP Association with UL Measurements

The following views were expressed on association of ARP (antenna reference point) with UL positioning measurements

* [Huawei, [1]]
  + Support reporting the location offset of the ARP relative to the TRP location with each measurement result.
    - The offset ARP can take
      * The WGS-84 representation similar to PRS ARP via delta longitude/latitude in the unit of milli-arc-second and delta height in the unit of {mm, cm, m}, or
      * The local coordinates representation via delta x, y, and z.
* [ZTE, [2]]
  + At least in the following conditions, gNB/TRP should be allowed to report ARP information of the TRP measurement results,
    - Measurement Beam Information is not requested by LMF.
    - The TRP only supports UL based positioning so that DL PRS resources are not configured.
    - The TRP only supports RP functionality.
  + The changes of antenna status (e.g., switch on and off some of panels or antenna groups) in TRP cannot inform LMF dynamically according to the current specification.
  + Even for a TRP with a single panel, the array phase center may not always be aligned with the ARP of a panel and lead to large impact on high accuracy positioning.
  + Report geographical coordinates of antenna groups may help to address the case when far-field assumption is not met between a UE and the TRP.
  + In order to improve positioning accuracy, Rel-17 should support reporting TRP measurement results being associated with ARP (Antenna Reference Point) information, consider at least one of the following options,
    - Option 1: A TRP should be allowed to provide a list of ARPs in TRP INFORMATION RESPONSE message. The ARP position is defined relative to the associated TRP position. Then, TRP is expected to optionally provide the ARP ID for the TRP measurement result in MEASUREMENT RESPONSE/REPORT message.
    - Option 2: A TRP can optionally provide the ARP position for the TRP measurement result in MEASUREMENT RESPONSE/REPORT message, wherein the ARP position is defined relative to the associated TRP position.
* [OPPO, [4]]
  + For each UL AoA, UL-TDOA, gNB Rx-Tx time difference and SRS-RSRP measurement result, the TRP can report the geographical coordinates of the antenna reference point that is used to measure the corresponding SRS resource(s) for measurement results.
    - The ARP location relative to the geographical coordinates for the TRP is provided for each UL measurement result.
* [CATT,[5] ]
  + It is preferable to support gNB reporting the ARP (Antenna Reference Point) information associated with UL-AoA, UL-TDOA, Multi-RTT measurements for the consistency of the DL and UL design.
    - Note: The ARP information includes the coordinates of the ARP relative to the coordinate of a TRP as defined in TS 38.455.
* [Nokia, [6]]
  + Support the gNB to report an AoA measurement and its associated ARP ID, where a group of antenna elements of the same ARP ID is assumed to see the same incident angle for a planar wave.
* [Fraunhofer, [11]]
  + Association of UL-AOA, UL-TDOA and Multi-RTT measurement results with ARP (Antenna Reference Point) information is supported
* [LGE, [13]]
  + The ARP may be replaced by TEG when the effective distance difference between ARPs is within timing error margin.
  + For consideration of supporting ARP for UL positioning measurement, first of all, RAN1 needs to consider/discuss the relationship between ARP and TEG.
* [vivo, [3]]
  + Do not support explicit association of UL-AOA measurement results with ARP information
* [Intel, [8]]
  + In case if DL PRS resources are configured, the association of the UL-AOA, UL-TDOA, and gNB Rx-Tx time difference measurements can be supported in Rel.16 standard by using the Measurement Result, Measurement Beam Information, and DL-PRS Resource Coordinates IEs as defined in TS 38.455
    - In that case the UL measurements can be associated with the receive beam information that contains the PRS Resource ID and PRS Resource Set ID
    - The PRS Resource ID and PRS Resource Set ID can be associated with the DL-PRS Resource ARP location
  + In case if gNB/TRP supports UL-based positioning only, the issue still can be solved by implementation, for example, different panels can be configured as different TRPs.
* [Samsung, [7]]
  + The association of UL-AOA, UL-TDOA, Multi-RTT measurements with ARP (Antenna Reference Point) information is NOT supported.
* [NTT DOCOMO, [9]]
  + Explicit association of UL positioning measurement results with ARP may not be needed
* [Ericsson, [17]]
  + Association of UL measurements with ARP is not introduced in rel-17

**Summary**

In summary, the following views were expressed:

* Do not support / do not see the strong need: 5 companies (reasons: functionality can be already supported by implementation, benefits are not clear)
* Support: 6 companies (reasons: consistency of DL and UL design, impact on performance / high accuracy positioning)
* More discussion is needed: One company proposed to discuss the relationship between ARP and TEG

It seems more discussion is needed to see if consensus can be reached.

### Round #1

In order to facilitate more discussion and mutual understanding among opponents and proponents, it is suggested to continue discussion and answer the following questions:

1. Q1: What are the benefits of specification- vs implementation-based solution in mentioned scenarios (e.g., UL only positioning, RP only scenario)?
2. Q2: Whether there is any scenario that may require use of two or more different solutions?
3. Q3: Whether ARP association with UL measurements also extended for UL timing measurements (i.e., UL-RTOA, gNB Rx-Tx time difference measurements)?

**Proposal 3.3-1**

* Continue discussion and provide answers on above questions

Comments from companies:

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## Aspect #4: Time Validity as Additional Assistance Signalling

The following views were expressed for association of antenna reference points with UL positioning measurements

* [Sony, [10]]
  + Support LMF to provide a time validity information associated with the expected AoA/ZoA range
  + Expected AoA/ZoA range assistance information can be explicitly indicated to be used for one positioning measurement.
* [vivo, [3]]
  + The time validity of the expected AoA/ZoA can be solved by gNB implementation or LMF implementation

**Summary**

This aspect has been discussed at the previous meeting. Based on inputs so far only one company shows interest to further improve assistance signaling framework while many companies mentioned that this aspect can be solved by LMF implementation. It seems challenging to reach consensus on this topic and thus it is proposed not to pursue this topic further in Rel 17.

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## Aspect #5: SRS for Positioning Power Control

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

* [OPPO, [4]]
  + 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.
  + 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.
* [Samsung, [7]]
  + The power setting for the SRS-pos might be not appropriate for neighbouring cell measurement.
  + The power control enhancement for SRS-pos to improve UL-AOA based solution should be considered.

**Summary**

This aspect has been discussed multiple meetings. Based on inputs so far only two companies have shown interest to further enhance open loop power control functionality. Many companies have expressed negative views including out of WI scope arguments. It seems challenging to reach consensus on this topic and thus it is proposed not to pursue this topic further in Rel 17.

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## Aspect #6: Beamforming and UL AOA Estimation

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

* [Nokia, [6]]
  + 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.
  + Study beam resolution control/recommendation by LMF for more accurate AoA measurement by beam interpolation based AoA estimation method based on RSRP measurements.
    - Request to gNB: beam resolution recommendation, number of RSRP measurement
* [Samsung, [7]]
  + The normal UL-AOA methods may not provide good enough estimation accuracy as well as latency.
  + The differential beamforming technique is beneficial for improving UL-AOA method to better satisfy the positioning requirement.
  + The gNB scheduling could ensure the proper SRS-pos configuration in order to support reception based on differential beam techniques.
  + Support differential beamforming technique for UL-AOA positioning methods.

**Summary**

This aspect has been discussed at the previous meetings. Based on inputs so far only two companies have shown interest to further enhance beamforming for UL-AOA. Many companies have expressed views that it can be left up to implementation. It seems challenging to reach consensus on this topic and thus it it proposed not to pursue this topic further in Rel 17.

Comments from companies:

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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#106bis-e meeting.

References

1. R1-2108731 Remaining issues of UL AoA enhancements Huawei, HiSilicon
2. R1-2108879 Accuracy improvement for UL-AoA positioning solutions ZTE
3. R1-2108976 Discussion on potential enhancements for UL-AoA method vivo
4. R1-2109052 Enhancements for UL AoA Positioning OPPO
5. R1-2109225 Further discussion on enhancements for UL-AoA positioning method CATT
6. R1-2109364 Views on enhancing UL AoA Nokia, Nokia Shanghai Bell
7. R1-2109491 Discussion on accuracy improvements for UL-AoA positioning solutions Samsung
8. R1-2109612 Remaining Aspects of NR Positioning UL-AoA Enhancements Intel Corporation
9. R1-2109680 Discussion on UL-AoA positioning enhancements NTT DOCOMO, INC.
10. R1-2109791 Considerations on enhancements for UL-AoA Sony
11. R1-2109863 TRP Rx-ARP information reporting Fraunhofer IIS, Fraunhofer HHI
12. R1-2110036 Positioning Accuracy enhancements for UL-AoA Apple
13. R1-2110089 Discussion on accuracy improvement for UL-AoA positioning LG Electronics
14. R1-2110134 Enhancements for UL-AoA positioning solutions InterDigital, Inc.
15. R1-2110188 Potential Enhancements on UL-AOA positioning Qualcomm Incorporated
16. R1-2110345 Discussion on enhancements for UL AoA positioning CEWiT
17. R1-2110350 Enhancements of UL-AoA positioning solutions Ericsson