3GPP TSG-RAN WG1 Meeting #103-e R1- 21NNNN

e-Meeting, January 25th– February 5th, 2021

Agenda Item: 8.5.3

Source: Moderator (Ericsson)

Title: FL summary for AI 8.5.3 Accuracy improvements for DL-AoD positioning solutions

Document for: Discussion, Decision

1. Introduction

This FL summary documents the proposals and discussions for agenda item 8.5.3, based on the following chairman decision:

[104-e-NR-ePos-03] Email discussion/approval on accuracy improvements for DL-AoD positioning solutions with checkpoints for agreements on Jan-28, Feb-02, Feb-05 – Florent (Ericsson)

The FL proposals are based on submission to AI 8.5.3 [1-21], but also including [16] and [21] which where submitted to AI 8.5.2 but contained proposals relevant to 8.5.3.

The proposals in the contributions centered on the following aspects:

Enhancements to UE reporting (LPP)

* Aspect #1 reporting of first path RSRP
* Aspect #2 support of NLOS identification
* Aspect #3 Adjacent beam reporting
* Aspect #4 Rx Beam reporting enhancements
* Aspect #5 CIR reporting for AoD
* Aspect #6 extension of number of reported RSRP measurements
* Aspect #7 Signalling to assist reference UE calibration

Enhancements to gnodeB signalling (NRPPa)

* Aspect #8 beam orientation error handling
* Aspect #9 gNodeB beam Shape information signalling
* Aspect #10 gnodeB based calculation of AOD
* Aspects #11 TRP antenna Array configuration signalling

1. Aspects for discussion

## UE Reporting aspects:

### Aspect #1 reporting of first path RSRP

#### Summary and FL proposal

Most companies support introducing an RSRP measurement of the earliest received path RSRP for a PRS resource configured for DL AoD, with some companies going further and support reporting more than one path, or the time difference between the first path received at each TRP [1][2][3] [7] [10][11][12][13][14][15][16][18][19][20]. The following proposals were submitted:

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| Source | Proposal |
| [1] | Proposal 3: The UE uses the LOS path of one DL PRS resource to measure the RSRP measurement report for DL-AoD.  Proposal 4: In DL-AoD measurement report, besides the RSRP measurement of DL PRS resources for each TRP, the UE also reports the relative time-of-arrival of those reported DL PRS resources of each TRP. |
| [2] | ***Proposal 2: Support path specific power reporting for DL-AoD positioning.*** |
| [3] | ***Proposal 1:*** *In addition to RSRP measurement, Rel-17 UE should have capability to support timing measurement for DL-AOD positioning method and report the timing information for network based positioning.* |
| [6] | ***Proposal 4***: Additional measurement with angle information relative to the first detected path should be further studied including its feasibility to improve AoD based positioning methods. |
| [7] | **Proposal 2**: Support timing based measurement and report for improving positioning accuracy of DL-AoD. |
| [10] | **Proposal 1: Introduce first path coefficient (Hfp) (i.e the amplitude of the first path in the received signal's power delay profile) in DL-AoD measurement report from UE to LS.** |
| [11] | **Proposal 1: Support the enhancement of reporting PRS-RSRP associated with ToA of the first arrival path.** |
| [12] | *Proposal 1: Report DL TDoA together with DL PRS-RSRP for DL AoD.*  *Proposal 2: To indicate the first arrival path by reporting the arrival time of each beam in beam measurement report.* |
| [13] | **Proposal 2: To improve the DL-AoD accuracy in UE-assisted mode, support enhanced UE measurements and reporting by considering the following:**   * **Reporting additional correlation information (ex. CIR reporting)** * **Reporting of the estimated first arriving path, multipath and noise power** * **Reporting of timing measurements on the DL-PRS resources along with the RSRP report.** |
| [14] | **Proposal 2-3**: The RSRP measurement may support the single path RSRP measurement. Therefore, new RSRP measurement definition could be needed |
| [15] | ***Proposal 1: For DL-AoD positioning method, UE can report the RSRP measurement for first arrival path together with a LOS/NLOS indicator.*** |
| [16] | **Proposal 1:** Support in Rel-17 that DL-PRS-RSRP calculation for each beam is associated to a time window in which the RSRP measurement is performed. |
| [18]. | ***Proposal 2: Support UE reporting of RSRP side information and additional measurements to improve the accuracy of the DL-AoD estimate, especially in NLOS scenarios. FFS details such as type of side information and timing measurements, aperiodic/periodic measurement windows, etc.*** |
| [19] | **Observation 1:**   * **Rel-17 can consider using other information (e.g. arrival path timings) in addition to RSRP for UE assisted DL-AoD positioning.** |
| [20] | **Proposal 1 Define a DL PRS peak-RSRP measurement for the power of a specific peak in the channel impulse response of a received DL-PRS resource.**  **Proposal 2 Include the DL PRS peak-RSRP in the NR DL-AoD Location Information alongside the existing DL PRS RSRP measurement.**  **Proposal 4 Include the DL PRS peak-RSRP in the NR DL-TDOA and multi RTT Location Information alongside the existing DL PRS RSTD measurement.**  **Proposal 5 The UE shall report the DL PRS Peak-RSRP and the corresponding DL PRS resource ID for each additional path in the RSTD and UE Rx-Tx time difference measurements.**  **Proposal 6 The UE shall report the strongest detected paths as additional paths (i.e. in addition to the first path).** |

Based on the set of proposals, it is proposed to have an initial agreement to support first-path RSRP measurement and reporting, while keeping open the additional details.

1. Support the DL-AOD enhancement of measuring and reporting PRS-RSRP based on first arriving path
   * FFS: Indication of the path arrival time
   * FFS: reporting of additional path to the first path.
   * FFS: Measurement definition
   * FFS: other method to support PRS-RSRP per path among OTDOA, UL TDOA

#### First round of comments

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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### Aspect #2 support of NLOS identification

#### Summary and FL proposal

The support of a LOS/NLOS detection/indication was brought up in [6][4][8][15][21].

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| Source | Proposal |
| [4] | Proposal 1: RSRP measurements can be associated with a LOS/NLOS identifier for supporting DL AOD positioning. |
| [6] | ***Proposal 1***: For the purpose of improving accuracy, methods to identify NLOS direction and the corresponding mitigation methods for DL-AoD measurements should be supported including the usage of transmissions and measurements of PRS signals with relative changes in their polarization orientation.  ***Proposal 2***: Consider reporting additional CIR measurements back to the network for improving NLOS detection and positioning accuracy.  ***Proposal 3***: To improve positioning accuracy by regularization techniques the UE should report LOS indicators as soft values for each link for UE-assisted positioning. |
| [8] | ***Proposal 3:***   * For the purpose of accuracy improvements, support enhancements so that the LMF knows a LoS direction of a TRP’s transmission beam to the UE. |
| [15] | ***Proposal 1: For DL-AoD positioning method, UE can report the RSRP measurement for first arrival path together with a LOS/NLOS indicator.*** |
| [21] | Proposal #3:  ● Support signaling indicating the LOS/NLOS link propagation type for DL-AOD positioning  ● Support signaling of reliability metric (with probability meaning) for NLOS detection (variable u in the range from 0 to 1, with absolute value showing reliability of decision) |

Since there is a variety of way to indicate LOS/NLOS on the proposals, we propose to agree on the principle of reporting LOS/NLOS information, and leave the details such as granularity (e.g. if the report is a binary indicator or a soft metric) to a future agreement.

1. For DL-AoD positioning method, UE can associate a measurement on a PRS resource with a report of LOS/NLOS state for the measurement
   * FFS: granularity of the state (binary indicator or soft metric)

#### First round of comments

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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### Aspect #3 adjacent beam reporting

#### Summary and FL proposal

To enhance the granularity of AOD estimation, several contributions proposed to report adjacent beams in addition to the “best beam”[1][5][8].

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| Source | Proposal |
| [1] | Proposal 2: In DL-AoD UE measurement reporting, support the UE to report the RSRP of a few DL PRS resources carrying adjacent Tx beam directions. |
| [5] | * ***Report up to 8 DL PRS-RSRP including the strongest PRS resource and adjacent PRS resources.***   Proposal 4:  • To balance the accuracy and robustness, AoD enhancement by adjacent DL PRS-RSRP and limited beam information (the intersection point of multiple beams) need to be considered. |
| [8]. | ***Proposal 2:***   * Need discussions on how to utilize the reception beam index for the accuracy improvements of DL-AoD based positioning, such as finding UE’s location when the UE is located between the transmission beams.   ***Proposal 5:***   * Consider enhancements for the accurate UE’s location estimation when the UE is located in between two different transmission beams. |

1. For DL-AoD positioning method, UE can associate a measurement on a PRS resource with an additional, adjacent PRS resources measurement
   * FFS: how to define / identify adjacent beams
   * FFS: required signaling to support use of adjacent beams

#### First round of comments

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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### Aspect #4 Rx Beam reporting enhancements

#### Summary and FL proposal

In [9], it was proposed to associate a Tx and Rx beam pair of indices with the RSRP report, indicating the beam pair resulting in the strongest RSRP. In [11], it is proposed to report the Rx beam information to the LMF. [3] proposed to enhance the report by providing detailed Rx beam information including antenna virtualisation and beam direction. In [7] it was proposed to enhance the report by informing the LMF of the Rx beams relative angular difference.

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| Source | Proposal |
| [9] | **Proposal 4: Introduce an indicator associated with a PRS resource/resource set or RX beam index to indicate TX beam or RX beam corresponding to the highest RSRP measurement.** |
| [11] | **Proposal 2: Support the enhancement of reporting the UE Rx beam information to the LMF. FFS the details of what/how to report the Rx beam information.** |
| [3] | ***Proposal 2:*** *Rel-17 NR positioning should support detailed Rx beam information, in which UE can provide its antenna virtualization and reception beam direction information.* |
| [7] | **Proposal 3*:*** Study angle difference measurements for AoA of DL PRS resources in Rel-17. |
| [8] | Proposal 1   * A further restriction would be required so that the UE uses a reception beam to avoid worst case of the reception beam selection, even if the UE can ignore QCL type-D configuration of the PRS resources to use a fixed reception beam for DL-AoD technique.   ***Proposal 2:***   * Need discussions on how to utilize the reception beam index for the accuracy improvements of DL-AoD based positioning, such as finding UE’s location when the UE is located between the transmission beams. |
|  |  |

1. For AOD, the UE may optionally indicate the following Rx beam information

A) An indicator that the reported resource gives the highest RSRP measurement

B) Rx beam direction information

C) Antenna virtualization for the Rx beam

D) angular difference between Rx beams when using different Rx beams.

#### First round of comments

Companies are encouraged to provide comments in the table below.

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### Aspect #5 CIR reporting for AoD

#### Summary and FL proposal

In [21] it was proposed to support reporting the complex channel coeffient per path for DL-AOD, for a number of channel taps. In [13], it is proposed to report the channel impulse response to be able to exploit correlation information.

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| Source | Proposal |
| [21] | **Proposal #1:**   * + **Support measured channel reporting per DL-PRS resource from UE to gNB to facilitate accurate DL-AOD estimation, including:**     - **Complex channel coefficient *h*(*m*) = *A*(*m*) × exp(*jφ*(*m*)) for the *m*th propagation path (channel tap) per DL-PRS resource:**       * ***A*(*m*) - channel amplitude for the *m*th propagation path; and/or**       * ***φ*(*m*) – channel phase for the *m*th propagation path** |
| [13] | **Proposal 2: To improve the DL-AoD accuracy in UE-assisted mode, support enhanced UE measurements and reporting by considering the following:**   * **Reporting additional correlation information (ex. CIR reporting)** * **Reporting of the estimated first arriving path, multipath and noise power** * **Reporting of timing measurements on the DL-PRS resources along with the RSRP report.** |

1. For DL AOD, support reporting of the measured complex channel, h(m) = A(m) × exp(jφ(m)) per path.

* FFS: details on the reporting (including whether to send phase and amplitude separately, quantization, number of paths, etc)

#### First round of comments

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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### Aspect #6 extension of number of reported RSRP measurements

#### Summary and FL proposal

In [4], it was proposed to increase the maximum number of measurements per TRP, in order to account for different RX beam. in [5] it is propose to either fix the RX beam for the 8 reported PRS RSRP, or introduce a new list of PRS Rx Beam indices to map the measurements to Rx beams.

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| Source | Proposal |
| [4] | ***Proposal 2: The maximum number of RSRP measurements per TRP for DL-AoD positioning should be increased for reporting the RSRP measured from different RX beams.*** |
| [5] | ***Proposal 5***   * ***To improve the accuracy of AoD and to avoid the impact of Rx beam, choose one of the following options.*** * ***Option 1: Report up to 8 DL PRS-RSRP corresponding to the same RX beam index*** * ***Option 2: Adding an additional DL PRS-RSRP list with different nr-DL-PRS-RxBeamIndex for a PRS resource.*** |

1. For DL AOD, the RSRP measurements per TRP is reported for

* Option 1 : up to 8 measurements per TRP per Rx beam index. Multiple measurements corresponding to different Rx Beam index may be reported for a given PRS.
* Option 2 : up to 8 measurements per TRP, for the same Rx beam index
* Option 3: up to N>8 measurements per TRP for all Rx beam indices, Multiple measurements corresponding to different Rx Beam index may be reported for a given PRS.

FFS: value for N.

#### First round of comments

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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### Aspect #7 Signalling to assist reference UE calibration

#### Summary and FL proposal

In [4], it was proposed to support calibration by a reference UE, by allowing to send measurement and location coordinates of a reference UE, as well as TRP beam characteristics, to the LMF. In [12] it is proposed to use a reference node with a very accurate knowledge of the node location to

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| Source | Proposal |
| [4] | ***Proposal 3: In order to improve DL-AOD estimation accuracy, the measurements provided by a reference UE with known locations should be supported to assist the calibration of the TRP transmitting beam direction.***   * ***The measurements and location coordinates of the reference UE are reported to LMF*** * ***The transmitting beam characteristics of TRP should be reported to LMF*** |
| [12] | *Proposal 3: Estimate the angle error by a reference node whose accurate location is known.* |

1. For DL AOD, support introducing high accuracy reporting of the UE location, for the purpose of supporting reference UEs.

#### First round of comments

Companies are encouraged to provide comments in the table below.

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## gNodeB signalling aspects

### Aspect #8 beam orientation error handling

#### Summary and FL proposal

Several contribution propose to account for the beam orientation error in the gnodeB[5][7].

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| Source | Proposal |
| [5] | ***Proposal 3***   * ***Beam orientation errors and potential correction mechanisms need to be considered in R17.*** |
| [7] | **Proposal 1:** RAN1 to study beam orientation errors and potential correction mechanisms in order to improve the positioning accuracy achievable with DL-AoD. Including:   * UE-based positioning: the beam offset (BO) could be signaled to the UE, as either an indicator, e.g. low/medium/high, each specifying an error range or as a specific value computed by the network * UE-assisted positioning: LMF should be aware of the BO and compensate for the errors when computing the position estimate. * Signaling aspects:   + LMF signals to TRPs that a BO recomputation and beam re-tuning is needed.   + UE measurement reports to facilitate BO identification and potential correction. |
| [18] | ***Proposal 3: Support mechanisms to consider beam orientation impairments and related assistance information for improving DL-AoD positioning accuracy.*** |

1. Support mechanisms to consider beam orientation impairments and related assistance information for improving DL-AoD positioning accuracy.
   * FFS: gnodeB and UE signalling to support beam orientation impairements mitigation.

#### First round of comments

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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### Aspect #9 gNodeB beam Shape information signalling

#### Summary and FL proposal

in [5][6] [11] [13] [14] [17], it is proposed to have the gnodeB transmit additional beam information to the LMF or the UE for AOD enhancements. In [4] it was proposed to support calibration by a reference UE, by allowing to send measurement and location coordinates of a reference UE, as well as TRP beam characteristics, to the LMF.

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| Source | Proposal |
| [4] | ***Proposal 3: In order to improve DL-AOD estimation accuracy, the measurements provided by a reference UE with known locations should be supported to assist the calibration of the TRP transmitting beam direction.***   * ***The measurements and location coordinates of the reference UE are reported to LMF*** * ***The transmitting beam characteristics of TRP should be reported to LMF*** |
| [5] | ***Proposal 2***   * ***Report additional beam information to the LMF or the UE for the enhancement of AoD.***   + ***E.g. intersection point of multiple beams:*** |
| [6] | ***Proposal 6***: Consider reporting beam-shape information to the UE for DL-AoD techniques. |
| [11] | **Proposal 3: Support the enhancement of reporting the gNB beam information to the LMF. FFS the details of what/how to report the beam information.** |
| [13] | **Proposal 1: Introduce the possibility to report the radiation characteristics of the transmitted PRS resources (i.e. main lobe power-level, sidelobe level, etc.).** |
| [14] | **Proposal 2-1**: It is preferred to have a table provided by each TRP which may characterize all the beam responses (EIRP) for covering a range of angles. The table is like a look-up table when UE reports a number of differential RSRP values for finding the angle between a TRP and UE  **Proposal 2-2**: A look-up table with differential EIRP across beams for a range of angles could also be considered |
| [17] | ***Proposal 1: For the purpose of enhancements to the RSRP-only DL-AoD method, support the signaling of beam responses (or equivalent information) to increase the accuracy precision while ensuring a tractable signaling overhead for both UE-based and UE-assisted solutions.***   * ***Note: For UE-Based AoD, the above signaling enhancements correspond to assistance data signaling (unicast or broadcast). For UE-Assisted DL-AoD, the above signaling enhancements correspond to NRPPa signaling enhancements from gNB to LMF.*** |

1. Support the enhancement of reporting the gNB beam information to the LMF.
   * FFS the details of what/how to report the beam information.

#### First round of comments

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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### Aspect #9 gnodeB based calculation of AOD

#### Summary and FL proposal

In [21], it was proposed to have the gnodeB report the calculated AOD to the LMF, using received measurement from the UE. The proposal relies on a companion proposal to support complex channel reporting from the UE to the gnodeB. In [2] it was proposed to support mechanisms to have the LMF request the gnodeB to calculate the AOD.

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| Source | Proposal |
| [21] | * + **Support DL-AOD reporting from gNB to LMF (or from gNB to UE), including:**     - ***φ* - azimuth angle of departure**     - ***θ* - zenith angle of departure** |
| [2] | ***Proposal 1: Support LMF to request angle calculation to the gNB for DL-AoD in Rel-17, i.e. the following Option from R3-197794.***   * ***The RAN nodes calculate the AoD with the RSRP information based on gNB configuration and send the AoD information back to LMF, who then calculates the UE position.*** |

1. DL-AOD reporting from gNB to LMF (or from gNB to UE) is supported

FFS: details on the report content

#### First round of comments

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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### Aspects #11 TRP antenna Array configuration signalling

#### Summary and FL proposal

In [21] and [17], it is proposed to provide additional information on the TRP antenna array configuration.

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| Source | Proposal |
| [21] | Proposal 4   * + **Support reporting of two DL-AOD azimuth angles *φ* and (π – *φ*) in addition to the zenith angle *θ* from gNB to LMF (or from gNB to UE)**   Proposal 5 **(Alternative to Proposal #4)**   * + **Specify the TRP antenna array orientation in the local coordinate system**   Proposal 6   * + **Support DL-AOD *φ’* = arcsin(sin(*φ*)×sin(*θ*)) angle reporting for the linear horizontal array, where *φ* is the azimuth angle of departure and *θ* is the zenith angle of departure**   + **Further discuss if it is necessary to indicate information on antenna array structure/type** |
| [17] | ***Proposal 2: For the purpose of enabling a phase-difference-based DL-AoD method, support the following signaling enhancements:***   * ***gNBs’ UPA antenna Configuration, PMI Codebook configuration & their association to the transmitted PRS resources*** * ***Note: Enhancement should be applicable to both UE-based and UE-assisted DL-AoD*** |

1. For both UE-based and UE-assisted DL-AoD, and for the purpose of supporting linear horizontal array types of gnodeB antenna configuration, consider the following options:
   * Support reporting of two DL-AOD azimuth angles *φ* and (π – *φ*) in addition to the zenith angle *θ* from gNB to LMF (or from gNB to UE)
   * Specify the TRP antenna array orientation in the local coordinate system
   * Support DL-AOD *φ’* = arcsin(sin(*φ*)×sin(*θ*)) angle reporting for the linear horizontal array, where *φ* is the azimuth angle of departure and *θ* is the zenith angle of departure
   * Support of signalling gNBs’ UPA antenna Configuration, PMI Codebook configuration & their association to the transmitted PRS resources

#### First round of comments

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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## Other Aspects for discussion

The following aspects have been proposed by one company. It is proposed to delay discussion on these issues to give a chance to other companies to consider these issues in future contributions.

### Aspect #8 Differential angle reporting

In [15] it was proposed to study angle difference measurement for the AOA of DL PRS.

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| Source | Proposal |
| [15] | ***Proposal 2: Support differential beamforming technique for DL-AOD positioning methods.***  ***Proposal 3: aspects of PRS resource configuration, DL transmission beam indication and UE measurement and report needs to be considered in order to support differential beamforming technique for DL-AOD positioning methods.*** |

### Signalling of preferred SSB

In  [8], it is proposed that the you may signal the preferred SSB to obtain timing mesasurements.

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| Source | Proposal |
| [8] | ***Proposal #4:***   * Support enhancements to enable the UE can use the reception beam in a direction corresponding to the minimum propagation time.   + E.g., the reporting of the preferred SSB to obtain timing measurements. |

### UE specific beam refinement

In [1] and [6] it was proposed to support configuring UE specific beam refinement on DL PRS resouces:

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| Source | Proposal |
| [1] | Proposal 1: To enhance the performance of DL AoD, support UE-specific beam refinement on DL PRS resource for DL-AoD measurement. |
| [6] | ***Proposal 5***: Consider two stage beam-sweeping for DL-AoD to improve angular resolution in a time and power efficient manner. |

### UE orientation reporting

In [9], it was proposed to include the UE orientation in the information reported to the LMF from the UE.

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| Source | Proposal |
| [9] | **Proposal 2: The UE should report its orientation information to the LMF.**  **Proposal 3: Define conditions for the UE to report the orientation.** |

### UE panel ID reporting

In [9], it was proposed to include the UE panel ID in the information reported to the LMF from the UE.

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| Source | Proposal |
| [9] | **Proposal 1: Include Rx panel ID in the measurement report.** |

# Conclusion

TBA

# References

1. R1-2100130 Enhancements for DL-AoD positioning OPPO
2. R1-2100238 Enhancement for DL AoD positioning Huawei, HiSilicon
3. R1-2100295 Accuracy improvements for DL-AoD positioning solutions ZTE
4. R1-2100387 Discussion on accuracy improvements for DL-AoD positioning solutions CATT
5. R1-2100447 Discussion on potential enhancements for DL-AoD method vivo
6. R1-2100489 Discussion on improving the accuracy of DL AoD positioning solutions FUTUREWEI
7. R1-2100550 Initial views on enhancing DL AoD Nokia, Nokia Shanghai Bell
8. R1-2100710 Discussion on accuracy improvement for DL-AoD positioning LG Electronics
9. R1-2100750 Accuracy improvements for DL-AoD positioning solutions InterDigital, Inc.
10. R1-2100864 Discussion on accuracy improvements for DL-AoD positioning method Sony
11. R1-2101048 Discussion on DL-AoD enhancement CMCC
12. R1-2101121 Accuracy improvements for DL-AoD positioning solutions Xiaomi
13. R1-2101133 DL-AoD positioning enhancements Fraunhofer IIS, Fraunhofer HHI
14. R1-2101141 Accuracy enhancement for DL-AOD technique MediaTek Inc.
15. R1-2101212 Accuracy improvements for DL-AoD positioning solutions Samsung
16. R1-2101388 Accuracy enhancements for UL-AoD positioning technique Apple
17. R1-2101470 Potential Enhancements on DL-AoD positioning Qualcomm Incorporated
18. R1-2101501 Potential DL-AoD Positioning Enhancements Lenovo, Motorola Mobility
19. R1-2101618 Discussion on DL-AoD positioning enhancements NTT DOCOMO, INC.
20. R1-2101756 Enhancements of DL-AoD positioning solutions Ericsson
21. R1-2100659 NR positioning enhancements for DL-AoD method Intel Corporation