3GPP TSG-RAN WG1 Meeting #106-e R1- 21NNNN

e-Meeting, August 16th – 27th, 2021

Agenda Item: 8.5.3

Source: Moderator (Ericsson)

Title: FL summary #1 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:

106-e-NR-ePos-03] Email discussion/approval on accuracy improvements for DL-AoD positioning solutions with checkpoints for agreements on August 19, 24 and 27 – Florent (Ericsson)

The FL proposals are based on submission to AI 8.5.3 [1-22] and treat the following aspects:

* Aspect #1 reporting of first path RSRP
* Aspect #2 extension of number of reported RSRP measurements
* Aspect #3 Adjacent beam identification in AD and reporting by the UE
* Aspect #4 Support of additional gnodeB beam information signalling
* Aspect #5 AoD uncertainty window
* Aspect#6 2-step beam refinement

In order to speed up progress, it is proposed to first consider proposals marked as high priority, and proceed with other proposal if time allows.

1. Aspects for discussion

## Main discussion topics

### Aspect #1 reporting of first arrival path

#### Summary

During RAN1#104e, an agreement was reached listing several options for reporting of the first arrival path and additional path:

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| Agreement:   * For both UE-based and UE-assisted DL-AOD study the following enhancements that enable the UE to measure and report (for UE-assisted) information related to the first arriving path   + Option 1: Information corresponds to PRS-RSRP of the first arriving path   + Option 2: Information corresponds to the angle of departure of the first arriving path   + Option 3: Information corresponds to the arrival time of the first path   + Option 4: Information corresponds to phase of the CIR corresponding to the first arriving path   + Option 5: Information corresponds to received signal value (amplitude and phase of the channel estimated from the first path which can be achieved as a combination of option 1 and option 4) of the first arriving path * FFS: Reporting of additional path to the first arriving path. * FFS: Measurement definition details * FFS: additional assistance data to support these enhancements * FFS: how the “first path” is selected among PRS resources in a PRS resource set * Note 1: Supporting multiple options as well as none of the options above is not precluded. |

The discussion continued in RAN1#105e and it was agreed to support measurement and reporting of the first path PRS-RSRP

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| Agreement:  For both UE-based and UE-assisted DL-AOD, the UE can be requested subject to UE capability to measure and report (for UE-assisted) the PRS RSRP of the first path   * FFS: Details of measurement and reporting of PRS RSRP of the first path |

In [[1][2][3][4][5] [7][9][10][13][14][15][16][21][22], companies have proposed solution to the following issues:

* Definition of first path RSRP [1][2][10][13][21]
  + Path RSRP is defined at the path time of arrival
  + Path RSRP is defined over a configured window[15][16]
  + Reported Relative to PRS RSRP [1][10][2][13]
* Reporting of first path RSRP is proposed to either:
  + Be included alongside RSRP
  + Be included as replacement for RSRP, with an indicator signaling which measurement is reported[5].
* Inclusion of path RSRP in other methods (multi RTT, DL TDOA)[13],[21]
* Support of further measurements beside power, e.g. phase[1][13], TOA[2][21], intra-TRP TDOA[9][2]
  + One company [3] suggested that the benefit of time information reporting should be clarified
  + One company [3] raises the issue of phase discontinuity regarding phase measurements (option 2,4,5), and propose to postpone angle based measurements to rel18.
* Assistance data to identify the first path [4]
* Reporting of multiple resources per set [7]
* Report triggering past a given threshold [14]
* Reporting of more than 1 path [21]
* Reporting of UE AoA and orientation[22]

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| Source | Proposal |
| [1] | ***Proposal 1: Support the phase reporting for the first path in DL-AoD.***  ***Proposal 2: Adopt the following definition of path RSRP.***   * ***FFS: the path RSRP measurement evaluation window*** * ***Send an LS to RAN4*** |
| [2] | ***Proposal 1:*** *The PRS RSRP of the first path is defined as the receiving power of the detected path used for the TOA value relative to the DL PRS-RSRP of the associated DL PRS resource.*   * *Send LS to RAN4 to design new mapping table according to the above definition.*   ***Proposal 2:*** *For UE-assisted DL-AOD, UE should be able to report information corresponds to the arrival time of the first path, which includes,*   * *Time of arrival( i.e. TOA) for at least one reference signal per TRP* * *Arrival time differences among reference signals from the same TRP (i.e. Intra-TRP TDOA)*   ***Proposal 3:*** *UE can report an indicator for each reported reference signal (or each DL PRS-RSRP value) to indicate that the sequence of arrival time of the first path derived from difference reference signals.* |
| [3] | ***Proposal 13***   * ***DL PRS reference signal received power of the first path (DL first path PRS-RSRP), is the linear average over the power components in the first path detected direction of power contributions (in [W]) of resource elements that carry DL PRS reference signals configured for RSRP measurements within the considered measurement frequency bandwidth.***   ***Proposal 14***   * ***Option 3 should be discussed after option 1 is being agreed upon.***   + ***Option 1: Information corresponds to PRS-RSRP of the first arriving path***   + ***Option 3: Information corresponds to the arrival time of the first path*** * ***The benefit of reporting timing information needs to be further clarified.***   ***Proposal 15***   * ***The performance benefits of Option 2, option 4, and option 5 should be evaluated first especially in phase inconsistency cases.***   + ***Option 2: Information corresponds to the angle of departure of the first arriving path***   + ***Option 4: Information corresponds to phase of the CIR corresponding to the first arriving path***   + ***Option 5: Information corresponds to received signal value (amplitude and phase of the channel estimated from the first path which can be achieved as a combination of option 1 and option 4) of the first arriving path***   **Proposal 16**   * ***The angle-based AoD positioning or phase-based AoD positioning are postponed to the future release.*** |
| [4] | **Proposal 5: Time window for PRS-RSRP and selection of the first path are UE implementation aspect.**  **Proposal 6: Support assistance information from LMF to UE to assist UE in selecting the first path.** |
| [5] | ***Proposal 1: An indicator of whether the report includes all paths or first arrival path only is supported.***  ***FL note: the indicator signal whether the RSRP is “all paths” (i.e. legacy) RSRP, or first arrival path RSRP.*** |
| [7] | **Proposal 1**: For DL-AoD support reporting of multiple PRS resources per PRS resource set, with each resource being associated with time of arrival information. |
| [9] | Proposal 6: In DL-AoD measurement report, support the UE to report the relative time-of-arrival of those reported PRS resources of each TRP. (i.e., Option 3). |
| [10] | ***Proposal 4: For the measurement & signaling of the earliest path RSRP, support the UE reporting, per PRS resource:***   * ***the relative received power of the earliest path over the total RSRP of the PRS resource.***    + ***Maximum value is 0 dB***   + ***Minimum value: [-30] dB***   + ***Step size: [0.5] dB*** |
| [13] | **Proposal 2**   * **For both UE-based and UE-assisted DL-AOD and DL-TDOA positioning methods, the UE can be requested to measure and report to LMF (for UE-assisted) the DL PRS-RSRP of the first path defined as follows:**   + ***RSRPFP* = 10 × lg(*P*0/*P*) in [dBm], *P*0 is the power of the first path, *P* is the total receive power corresponding to the measured DL PRS-RSRP value within the considered measurement frequency bandwidth**   + **If receiver diversity is used by the UE, then the reported DL PRS-RSRP of the first path should not be lower than the corresponding DL PRS-RSRP of the first path of any of individual receiver branches**   + **The *RSRPFP* parameter is defined in the finite range [-X, 0], where X defines some threshold in [dBm] identifying the level of sensitivity for receive power**   + **The granularity (or step size) of the measured *RSRPFP* parameter is set equal to Y in [dBm], identifying the sufficient level of accuracy, required in the measurements**   + **FFS: X in [dBm], Y in [dBm] (up to RAN4 discussion)**   **Proposal 3**   * **For UL-AOA and UL-TDOA positioning methods, the gNB can be requested to measure and report the UL SRS-RSRP of the first path to LMF**   **Proposal 4**   * **For Multi-RTT positioning method:**   + **the UE can be requested to measure and report the DL PRS-RSRP of the first path to LMF**   + **the gNB can be requested to measure and report the UL SRS-RSRP of the first path to LMF**   **Proposal 5**   * **For UE-assisted DL-AOD positioning method, the UE can be requested to measure and report to LMF the phase of the first path** |
| [14] | **Proposal 1: For both UE-based and UE-assisted DL-AoD, the UE reports the PRS RSRP of the first path once the RSRP, accumulated over a preconfigured duration, is above the threshold configured by the LMF** |
| [15] | **Proposal 1**: For DL-AoD technique, support PRS-RSRP measurement within a configured time window wherein the power of paths out of the window, if any, does not contribute in PRS-RSRP.   * Alternatively, or additionally, for DL-AoD technique, support PRS-RSRP for the first arrival path only that is measured within a configured time window. |
| [16] | **Proposal 2-1**: Define per-path RSRP at pre-DFT domain  **Proposal 2-2**: The pre-DFT domain is defined as the domain after transforming by IDFT the channel frequency response value at resource elements that carry DL PRS reference signals within the considered measurement frequency bandwidth  **Proposal 2-3**: The RSRP for a single path could be defined as the sum over the power contributions(in [W]) of the taps within a measurement window at the pre-DFT domain  **Proposal 2-4**: For the CIR observation of each DL-PRS resource, the measurement window for a certain path is considered to be identical across the resources. The size and range of the measurement window could be determined by UE |
| [21] | **Proposal 1 Include DL PRS-RSRP-PP of the first path in NR DL-AoD Location Information alongside the existing DL PRS-RSRP measurement.**  **Proposal 2 Include DL PRS-RSRP-PP of the first path in the NR DL-TDOA Location Information and in NR multi-RTT Location Information alongside the existing DL PRS RSRP measurement.**  **Proposal 3 The DL PRS-RSRP-PP is reported together with an associated timing measurement of the corresponding path.**  **Proposal 4 Include additional paths in the DL-AOD measurement report. For each additional path the DL PRS-RSRP-PP and the associated timing measurement should be reported.** |
| [22] | **Proposal 1:** **For DL\_AoD based positioning,** **the standards should support reporting of FAP- RSRP and FAP-RTOA measurements by UE.**  **Proposal 2: For DL\_AoD based positioning, the standards should also support reporting of FAP-UE-AoA and UE-orientation measurements by UE to LMP.** |

Based on the contributions, the following is proposed on aspect #1:

#### Proposal 1.1 (high priority proposal)

#### First round of discussion

**Proposal 1.1: For definition of the PRS RSRP per path,**

* **Option 1: the path PRS RSRP correspond to the power of the channel impulse response at a given path delay**
* **Option 2: the path PRS RSRP correspond to the accumulated power of the channel impulse response over a time window** 
  + **FFS: how is the window conveyed to the UE (i.e. fixed in specification or configured in measurement request)**
* **FFS further details of the definition**

Companies are encouraged to provide comments in the table below.

**Proposal 1.1**

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| --- | --- |
| **Company** | **Comment** |
| vivo | We prefer that the following online proposal is seen as start point  Alternate Proposal:  The measured path PRS RSRP is the power of the channel impulse response at a certain path delay.   * Up to RAN4 to define any test/requirement for the measurement. * Send LS to RAN4 informing them of this agreement after completion of further discussion. |
| Qualcomm | We are OK with the alternate proposal by Mr Chairman, but, as we pointed out, the „power“ could correspond to relative power with respect to PRS RSRP (related to the next proposal). We suggest to combine this alternate proposal with the options shown below (or best, if we can agree from the beginnign with Option 1 from the Propsoal 1.2) |
| MTK | It seems no harm to add a note for the alternate proposal, since most companies have studied and understood how to do the measurement by having a time window. The note doesnt need to explicitly describe time window, just to describe the relationship between a given path delay and sampling point/sampling grid  Alternate Proposal:  The measured path PRS RSRP is the power of the channel impulse response at a certain path delay.   * Note: a certain path delay is independent of any point on the sampling grid * Up to RAN4 to define any test/requirement for the measurement. * Send LS to RAN4 informing them of this agreement after completion of further discussion. |
| ZTE | The same view with Qualcomm.  To MTK, we prefer not to add a note. RAN4 will make their decision. |
| Intel | Support the alternate proposal. Agree to define the relative power with respect to the PRS RSRP. |
| Fraunhofer | We are fine with the alternate proposal and the note added by MTK. |
| Huawei, HiSilicon | OK with MTK’s revision or Chair’s alternative proposal.  As commented by QC, we also think that there should be some “normalization rule” to define path RSRP in the same order of the existing RSRP, which is the mean Rx EPRE. Technically, it is not clear to what path power would refer, e.g. expressed in dBm or something else.  Another issue is that it may depend on whether absolute requirement is defined or only relative requirement is defined. For the purpose DL-AoD, we think relative path RSRP (the same first path across multiple PRS resources) should be sufficient. By relative path RSRP, I am not saying the relative value to the Rel-16 PRS RSRP (all path RSRP), but rather the relative value for the same path between different beams.  Therefore, we would suggest to add the following sub-bullet.   * Up to RAN4 to define absolute or relative or both requirements. |
| CATT | We support the alternate Proposal. We prefer to define the path PRS PRSP and related performance requirements in RAN4. |

#### Proposal 1.2 (high priority proposal)

#### First round of discussion

**Proposal 1.2: For reporting of the PRS RSRP per path,**

* **Option 1: the PRS RSRP per path is reported relative to the PRS RSRP, and together with PRS RSRP in the same measurement report**
* **Option 2: the PRS RSRP is reported either per path or for all path (rel16 PRS RSRP) in the same measurement report** 
  + **FFS: use of an indicator to distinguish the two measurements**
* **FFS further detail of the report formatting, including granularity**

Companies are encouraged to provide comments in the table below.

**Proposal 1.2**

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| --- | --- |
| **Company** | **Comment** |
| vivo | Same comment in online, we suggest modify the PRS RSRP per path to path PRS RSRP  And for the two option, option 1 is preferred. |
| Qualcomm | Option 1 |
| MTK | Option 1 provides more information to LMF. Seems better |
| ZTE | Option 1 |
| Intel | Option 1 |
| Fraunhofer | Prefer Option 1. |
| Huawei, HiSilicon | It depends on whether the absolute RSRP requirement is defined or not. We prefer to let RAN4 work out.  For DL-AoD, we think what is useful is the relative path RSRP for the same path across multiple resources. Whether the relative value with the Rel-16 PRS RSRP is accurate does not matter that much. |
| CATT | We prefer Option 1. |

#### Proposal 1.3 (high priority proposal)

#### First round of discussion

**Proposal 1.3**

**The PRS-RSRP per path report can include measurements from multiple PRS resources in the same resource set**

* **FFS: use of intra-TRP TDOA when reporting more than 1 PRS per TRP.**

Companies are encouraged to provide comments in the table below.

**Proposal 1.3**

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| **Company** | **Comment** |
| vivo | We are confused with the proposal. Is there any other works needs to be done except adding the highlight IE as follows.  -- ASN1START  NR-DL-AoD-SignalMeasurementInformation-r16 ::= SEQUENCE {  nr-DL-AoD-MeasList-r16 NR-DL-AoD-MeasList-r16,  ...  }  NR-DL-AoD-MeasList-r16 ::= SEQUENCE (SIZE(1..nrMaxTRPs-r16)) OF NR-DL-AoD-MeasElement-r16  NR-DL-AoD-MeasElement-r16 ::= SEQUENCE {  dl-PRS-ID-r16 INTEGER (0..255),  nr-PhysCellID-r16 NR-PhysCellID-r16 OPTIONAL,  nr-CellGlobalID-r16 NCGI-r15 OPTIONAL,  nr-ARFCN-r16 ARFCN-ValueNR-r15 OPTIONAL,  nr-DL-PRS-ResourceID-r16 NR-DL-PRS-ResourceID-r16 OPTIONAL,  nr-DL-PRS-ResourceSetID-r16 NR-DL-PRS-ResourceSetID-r16 OPTIONAL,  nr-TimeStamp-r16 NR-TimeStamp-r16,  nr-DL-PRS-RSRP-Result-r16 INTEGER (0..126),  nr-DL-PRS-Path-RSRP-Result-r17 INTEGER \*\*\*  nr-DL-PRS-RxBeamIndex-r16 INTEGER (1..8) OPTIONAL,  nr-DL-AoD-AdditionalMeasurements-r16  NR-DL-AoD-AdditionalMeasurements-r16 OPTIONAL,  ...  }  NR-DL-AoD-AdditionalMeasurements-r16 ::= SEQUENCE (SIZE (1..7)) OF  NR-DL-AoD-AdditionalMeasurementElement-r16  NR-DL-AoD-AdditionalMeasurementElement-r16 ::= SEQUENCE {  nr-DL-PRS-ResourceID-r16 NR-DL-PRS-ResourceID-r16 OPTIONAL,  nr-DL-PRS-ResourceSetID-r16 NR-DL-PRS-ResourceSetID-r16 OPTIONAL,  nr-TimeStamp-r16 NR-TimeStamp-r16,  nr-DL-PRS-RSRP-ResultDiff-r16 INTEGER (0..30),  nr-DL-PRS-Path-RSRP-ResultDiff-r16 INTEGER \*\*\*  nr-DL-PRS-RxBeamIndex-r16 INTEGER (1..8) OPTIONAL,  ...  }  -- ASN1STOP |
| Qualcomm | Same view as vivo; isnt that the obvious way we ll specify it? |
| MTK | This proposal is quite intuitive. What is more important is when UE measure path RSRP for multiple PRS resources within a same set, the location of given path delay needs to be the same among measurements for the PRS resources. We believe that RAN1 needs to specify this. This is not RAN4 job  We dont see the use case that UE reports path RSRP with different path delays among PRS resources  So we suggest to modify the proposal as,  **The PRS-RSRP per path report can include measurements from multiple PRS resources in the same resource set, with same path delay for the measurements** |
| ZTE | Similar to PRS RSRP, which is reported per DL PRS resource. We don’t need to discuss this proposal. |
| Intel | It is unclear, do we assume the same path delay or different path delays across the PRS resources for the first arrival path RSRP measurements? |
| Huawei, HiSilicon | To our understanding, Rel-16 does not restrict the PRS-RSRP reported across multiple sets per TRP.  We do see some value for reporting path RSRP for different sets, e.g. the first set uses DFT beam and the second set uses differential beam. How the reporting is done depends on Aspect #3. |
| CATT | We share the similar view with vivo and Qualcomm. We just need to add the highlighted IEs in vivo’s comments. |

#### Proposal 1.4

#### First round of discussion

**Proposal 1.4**

**The PRS-RSRP per path report can include the phase of the measured path.**

Companies are encouraged to provide comments in the table below.

**Proposal 1.4**

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| **Company** | **Comment** |
| Qualcomm | Too late for this release for us, lets focus on closing the issues. |
| Intel | Support |
| Huawei, HiSilicon | Support. We think if there is phase discontinuity, it can be estimated by the PRU. |
| CATT | We prefer this issue to be low priority. |

#### Proposal 1.5

#### First round of discussion

**Proposal 1.5:**

**The PRS-RSRP per path report can include the time of arrival of the measured path.**

* **FFS: use of intra-TRP TDOA when reporting more than 1 PRS per TRP.**

Companies are encouraged to provide comments in the table below.

**Proposal 1.5**

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| **Company** | **Comment** |
| Qualcomm | Not support. |
| ZTE | Support. In order to get path RSRP, UE of course has to get the first detected path first. The TOA and intra-TRP can benefit LMF to identify which resource corresponds to LOS direction when LOS path is blocked. However, path RSRP cannot do this if RSRP for LOS path is smaller that RSRP for NLOS path. |
| CATT | Support. We think it is useful to include the ToA of the measured path with the path PRS-RSRP reporting. |

#### Proposal 1.6

#### First round of discussion

**Proposal 1.6:**

**Reporting of PRS RSRP per path is supported for DL-TDOA and multi RTT.**

Companies are encouraged to provide comments in the table below.

**Proposal 1.6**

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| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Related to PDP reporting in other subagenda. Discuss it there. |
| ZTE | We should focus on DL-AOD first. |
| Intel | We would prefer to consider it in the NLOS/multipath agenda item. |
| CATT | We think this issue can be discussed in AI 8.5.5 to avoid potential duplicated discussion. |

#### Proposal 1.7

#### First round of discussion

**Proposal 1.7:**

**The measurement report for AoD can include the UE AoA measurement and UE orientation.**

Companies are encouraged to provide comments in the table below.

**Proposal 1.7**

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| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Not support. UE AoA is the first time that we are discussing; too late to open this issue now. |
| ZTE | Open for further discuss. |
| Intel | This is OK for the PRU, so we can be supportive for the PRU only. In general case the orientation of the UE antenna is not known. |
| CATT | We prefer this issue to be low priority. |

#### Proposal 1.8

#### First round of discussion

**Proposal 1.8:**

**The measurement reporting of PRS-RSRP per path for DL-AoD can be configured to be conditioned to a predefined threshold.**

Companies are encouraged to provide comments in the table below.

**Proposal 1.8**

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| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Unnecessary optimization or unclear the usefulness. Further discussion/motivation may be needed. |
| ZTE | RAN4 will decide the mapping table for path RSRP. There is no need to have such threshold. |
| CATT | We prefer to discuss this issue in RAN4. |

### Aspect #2 extension of number of reported RSRP measurements

#### Summary and Proposal 2.1

During RAN1#104e, it was agreed to select from 3 options regarding the number of RSRP measurements:

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| Agreement:  For UE-assisted DL AOD, select one of the following options for reporting of RSRP measurements per TRP   * Option 1: Up to 8 measurements in a measurement report (as in release 16) * Option 2: Up to 8 measurements in a measurement report, for the same Rx beam index * Option 3: Up to N>=8 measurements   + Note: Multiple measurements corresponding to different Rx Beam index may be  reported for a given PRS resource.   + FFS: value for N. |

As in RAN1#105e, there is a majority of companies supporting an increase of the maximum number of PRS measured and reported via *NR-DL-AoD-MeasElement-r16*

* [3][6][7][8][10] [11] want to increase the number of measurements to be reported
* [9][15] want to stay with release 16 measurements capacity of 8 measurements in *NR-DL-AoD-MeasElement-r16*.

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| Source | Proposal |
| [3] | ***Proposal 17***   * ***To improve the accuracy of DL-AoD and to avoid the impact of Rx beam, choose one of option 2 and option 3.***    + ***Option 2: Up to 8 measurements in a measurement report, for the same Rx beam index***   + ***Option 3: Up to N>=8 measurements***     - ***Note: Multiple measurements corresponding to different Rx Beam index may be reported for a given PRS resource.***     - ***FFS: value for N.*** |
| [6] | ***Proposal 1: For UE-assisted DL-AoD, the maximum number of RSRP measurements per TRP should be increased from 8 to [16]. Whether to support reporting more than 8 RSRP measurements per TRP can be subject to UE capability.*** |
| [7] | **Proposal 2**: Support “Option 3: Up to N>8 measurements” as candidate enhancement. FFS value of N. |
| [8] | ***Proposal 2: Up to N>=8 measurements in a measurement report for reporting of RSRP measurement per TRP.*** |
| [9] | Proposal 5: For UE-assisted DL AoD, support Option1, up to 8 RSRP measurements in a measurement report (as in release 16). |
| [10] | ***Proposal 7: For UE-A DL-AOD, support reporting more than 8 RSRP measurements per TRP.***   * ***Note: Multiple RSRPs corresponding to same or different Rx Beam index should be able to be reported for a given PRS resource for different timestamps.*** * ***FFS: Value for N*** |
| [11] | **Proposal 1: For UE-assisted DL AOD, support up to N>=8 measurements for reporting of RSRP measurements per TRP.** |
| [12] | ***Proposal 2:***   * 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 3:***   * 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. |
| [15] | **Proposal 2**: For reporting of RSRP measurements per TRP, subject to UE capability, support Option 1, i.e. up to 8 measurements in a measurement report, as in release 16. |

#### First round of discussion

It is proposed to continue discussing the proposal brought up during the last e-meetings. Considering the number of issues to be discussed during the meeting, this issue is given a lower priority.

As a side note, it should be understood one “measurement” in the proposal correspond to the measurement reported for a PRS for a given Rx-beam. The total number of measurements in a report should include the adjacent beams reporting (if agreed) as well as multiple Rx beams measurement for the same PRS.

**Proposal 2.1**

**For UE-A DL-AOD, support reporting more than 8 measurements per TRP.**

* **Note: Multiple RSRPs corresponding to same or different Rx Beam index should be able to be reported for a given PRS resource for different timestamps.**
* **FFS: Value for N**

Companies are encouraged to provide comments in the table below.

**Proposal 2.1**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Even though we are supportive, this is low priority, and prefer not to spend time on it online. |
| ZTE | Okay for this. But we don’t expect that more that 8 DL PRS RSRPs are associated with the same Rx beam index. In order to provide more information for LMF to decide which Rx beam index is the best, we should limit the maximum number of DL PRS RSRP associated with the same Rx beam index.  We would like to have another FFS,  FFS: Limit the maximum number of DL PRS RSRP associated with the same Rx beam index |
| Intel | Low priority |
| Fraunhofer | Support, N= 16. |
| CATT | Support this proposal and we prefer to discuss this issue with high priority.  For UE-assisted DL-AoD, the maximum number of RSRP measurements per TRP should be increased from 8 to [16]. Whether to support reporting more than 8 RSRP measurements per TRP can be subject to UE capability. And we are fine to limit the the maximum number of DL PRS RSRP associated with the same Rx beam index. |

### Aspect #3 adjacent beam reporting

#### Summary

During RAN1#104b-e, the following agreement was made:

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| Agreement:  Support the following enhancements under UE capability for both UE-B and UE-A DL-AOD positioning method   * Enhancing the signaling to UE for the purpose of PRS resource(s) measurement and (for UE-A) report   + FFS: The detailed signaling (e.g, the boresight direction for UE-A DL-AoD, further spatial information of PRS resources, processing prioritization of PRS resources). * FFS: The following options   + Option 1: Enhancing the reporting to include the measurements of adjacent beams PRS resources that related with each other indicated by the assistance data.   + Option 2: UE can be requested to measure and report on specific PRS resources. |

The discussion progressed in RAN1#105e and the following agreement was made:

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| Agreement:  For UE-assisted DL-AOD positioning method, select one or more of the following to enhance the signaling to the UE for the purpose of PRS resource(s) measurement and reporting:   * Option 1: the LMF explicitly identify adjacent beams in the assistance data (AD) * Option 2: the LMF send the beam information in the AD with an order of priority of PRS resources. * Option 3: the LMF includes boresight direction information for each PRS resource in the assistance data. * Option 4: the LMF send the beam information in the AD with indicated subset of PRS resources. * FFS: Detailed signaling and procedure * FFS: How to define adjacent beams |

The proposals in [1][3][4][5][6][7][8][9][10][12][14][16][18][19][20][21] can be summarized as follow:

* There is a strong correlation between proposals supporting option 1 and 4, i.e. supporting having the assistance data organized in subsets where each subset correspond to a beam and its associated/adjeacent beams. In [1][3][5] [6][9][12][19][21], it is proposed to organize to AD in subsets of PRS resources. [18] proposes to identify adjacent resources by resource index.
* [3][6][8][2][14][16][20] proposed to also support option 3 (boresight direction)
* [10][20] see the issue as a PRS prioritization discussion
* [4][7] see the issue as low priority or do not support the enhancement

Based on the proposals, it is propose to introduce adjacent beams by signalling the subsets of PRS beams adjacent to a given PRS. The impact on PRS processing priority should be discussed further. For example, whether the UE should process all “main beams” before processing “adjacent beams” or vice versa. Given the support for signaling of boresight direction, it is also proposed to be supported.

|  |  |
| --- | --- |
| Source | Proposal |
| [1] | ***Proposal 3: For dealing with assistance data to indicate the “adjacent beams”, select Option 4.***   * ***Option 4: the LMF sends the beam information in the AD with indicated subset of PRS resources.*** * ***Note: Option 2 can be discussed if PRS resource level priority is introduced.***   ***Proposal 4: Support indicating for a PRS resource (resource A) a subset of PRS resources (subset B) in the assistance data, and if UE reports RSRP of the resource A as the main result of DL-AoD, UE shall include the RSRP of the resources in the corresponding subset B.*** |
| [3] | ***Proposal 10***   * ***Support option 3 at least that providing the boresight direction of PRS resource to UE for UE-A DL-AoD.***   **Proposal 11**   * ***Support option 4 at least that providing expected AoD information to indicate that subset of PRS resources within it is a high priority to be measured and reporting.***   ***Proposal 12***   * ***DL-AoD measurement and reporting with the subset of PRS resources can be requested when the requirement of latency and power consumption is tight .*** |
| [4] | **Proposal 1: Down-prioritize the usage of assistance data (AD) to indicate adjacent beam. The similar enhancements can be obtained by on-demand PRS operation and/or two-stage beam sweeping to enable LMF to indicate specific PRS resources.** |
| [5] | ***Proposal 4: For UE-assisted DL-AOD positioning method, support that the LMF sends the beam information in the assistance data with indicated subset of PRS resources.***  ***Proposal 5: For DL-AoD, LMF can request UE to measure and report on specific PRS resources***   * ***FFS: whether by implicit rules and/or explicit signaling*** |
| [6] | ***Proposal 2: For UE-Based and UE-Assisted DL-AOD positioning method in Rel-17, both option 1 and option 3 of the agreement of the last meeting should be supported:***   * ***Option 1: The LMF explicitly identify adjacent beams in the assistance data (AD)*** * ***Option 3: The LMF includes boresight direction information for each PRS resource in the assistance data*** |
| [7] | **Proposal 5**: Do not support enhancements for adjacent beam reporting (i.e., do not support option 1). |
| [8] | ***Proposal 1: For UE-assisted DL-AOD positioning method, downselect between the following to indicate adjacent beams in the signalling to the UE, we prefer option 4: the LMF send the beam information in the AD with indicated subset of PRS resources.*** |
| [9] | Proposal 3: For DL-AoD positioning method, support Option 1, i.e., LMF indicates adjacent beams in assistance data:   * In the assistance data of PRS configuration, the UE is provided with configuration information that indicates which PRS resources are associated with each other in spatial domain. * In measurement report, if the UE reports RSRP of one PRS resource, the UE also reports the RSRP of PRS resources that are associated with that PRS resource. |
| [10] | ***Proposal 6: With regards to PRS resource Prioritization for DL-AoD measurements, support LMF providing in the assistance data support both of the following options:***   * ***Opt. 3: Boresight direction of each PRS resource (already supported for UE-B, but not for UE-A)*** * ***Opt. 2: Prioritization information (e.g. prioritization based on the ordering in the PRS resource set as was discussed during NR Rel-16).*** |
| [12] | ***Proposal 1:***   * For UE-assisted DL-AOD positioning method, select Option 4 (‘the LMF send the beam information in the AD with indicated subset of PRS resources’) |
| [14] | **Proposal 3: Support Option 3 (The LMF includes boresight direction information for each PRS resource in the assistance data)** |
| [16] | **Proposal 3-1**: Support that LMF includes boresight direction information for each PRS resource in the assistance data |
| [18] | *Proposal 1: Adjacent PRS resources can be predefined by resource index.* |
| [19] | **Proposal 1: The LMF sends beam information in the AD with the indicated subset of PRS resources (Option 4).** |
| [20] | ***Proposal 1: Support Option 2 of transmitting the beam information in the AD with an explicit order of priority of PRS resources. Explicit priority indications can be signaled in the AD. Send LS to RAN2 to confirm signalling.***  ***Proposal 2: Support Option 3 to extend the current framework of providing boresight information in the case of UE-assisted DL-AoD positioning.***  ***Proposal 3: Reporting of beam information corresponding to Option 2, can be implicitly performed using the same prioritization order provided in the AD as configured by the LMF.*** |
| [21] | **Proposal 7 For UE-assisted DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s) measurement and reporting: the LMF explicitly identify adjacent beams in the assistance data (AD). (Option 1 in the agreement at RAN1#105e)**  **Proposal 8 The ordering of the beams in two dimensions is supplied to the UE as assistance information in one of the following formats: (1) For each DL PRS Resource, one list of neighbors in dimension 1 and another list of neighbors in dimension 2. (2) For each DL PRS Resource, one list of general neighbors.**  **Proposal 9 The UE should report the DL PRS-RSRP-PP measurement for the DL PRS Resource with the highest first path DL PRS-RSRP-PP measurement and all its neighbors.**  **Proposal 10 First path DL PRS-RSRP-PP measurements of adjacent DL PRS Resources that the UE reports should be performed using the same Rx-beam.** |

#### Proposal 3.1 (high priority proposal)

#### First round of discussion

**Proposal 3.1:**

**For UE-assisted DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s) measurement and reporting, the LMF explicitly identify adjacent beams in the assistance data (AD) by signalling for each PRS resource a subset of PRS resources to be identified as adjacent to the PRS resource.**

**-FFS: how to distinguish between adjeacent resources in elevation and azimuth**

**-FFS: the impact of processing adjacent beams on PRS processing prioritizations**

Companies are encouraged to provide comments in the table below.

**Proposal 3.1**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| vivo | Agree with the intention, and revise some wording as follows  **Proposal 3.1:**  **For UE-assisted DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s) measurement and reporting, the LMF explicitly identify adjacent beams in the assistance data (AD) by signalling for each PRS resource in a subset of PRS resources to be identified as adjacent to the PRS resource.**  **-FFS: how to distinguish between adjacent resources in elevation and azimuth**  **-FFS: the impact of processing adjacent beams on PRS processing prioritizations** |
| Qualcomm | Not support. This feature can be supported by just reusing the boresight directions + expectedAoD. |
| ZTE | Not support. The same view as Qualcomm. |
| Fraunhofer | Support.  When considering Rel-17 enhancements for AoD, the boresight information will not be sufficient and can be also misleading. For UE-A, reduced information worsens the performance, which to overcome requires high signaling overhead that is not justified. |
| Huawei, HiSilicon | Support with revision:  **Proposal 3.1:**  **For UE-assisted DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s) measurement and reporting, the LMF indicates in the assistance data (AD) for each PRS resource a subset of PRS resources.**    **-FFS: the impact of processing the subset of PRS resources** |
| CATT | Support the vivo’s version.  In addtion, we think the following option is also can be included as the potential solution:   * The LMF includes boresight direction information for each PRS resource in the assistance data |

#### Proposal 3.2 (high priority proposal)

#### First round of discussion

**Proposal 3.2:**

**For UE-assisted DL-AOD positioning method, the LMF can include boresight direction information for each PRS resource in the assistance data.**

Companies are encouraged to provide comments in the table below.

**Proposal 3.2**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| vivo | Support |
| Qualcomm | Support (together with expectedAoD so that this proposal is useful) |
| ZTE | Support |
| Fraunhofer | Don’t Support.  We think that boresight information can be usefull but not sufficient on its own. Additional AD, considering enhancements in this WI, related to prominent sidelobes due to antenna radiation imperfections, the azimuth/elevation information associated with main and sidelobes or beamwidth information needs to be provided as well for the UE to select the right “adjacent” PRS resources. |
| Huawei, HiSilicon | Do not support.  There is no clear UE behaviour defined for using the boresight direction. What can network expect from UE through providing the boresight direction? Are supporting companies willing to mandate how UE should process PRS with this AD? |
| CATT | Support as we had commented in proposal 3.1. |

### Aspect #4 Support of additional gnodeB beam information

#### Summary

The following agreement was reached during RAN1#104b:

|  |
| --- |
| Agreement:  Regarding support of angle calculation enhancement for DL-AoD:   * Support gNB providing the beam/antenna information to the LMF.   + The gNB beam/antenna information can be provided to the UE for UE-based DL-AoD   + FFS: the details of contents of the beam/antenna information   + FFS: the details of how to provide the beam/antenna information.   + Note: The antenna information is related to reducing the overhead of beam information * Send an LS to RAN2/RAN3 regarding the option of angle report from gNB to LMF for UE-A DL-AoD requesting them to consider this option in Rel-17. |

The following two options were agreed to be further discussed during RAN1#105e:

|  |
| --- |
| Agreement:  For the beam/antenna information to be optionally provided to the LMF by the gnodeB, select one or more of the following:   * Option 1: the gNB reports the antenna configuration including at least the following parameter:   + the number of antenna elements (vertical and horizontal)   + antenna spacing dh and dv   + FFS: For DFT-based beams, precoder information for each PRS resource     - Check whether the already reported boresight directions are sufficient, or whether more information is needed   + FFS: Antenna Element pattern Information     - FFS: Details   + FFS: If additional information about panel/orientation is needed * Option 2: the gNB reports a mapping of angle and beam gains for each of the PRS resources.   + FFS: representation of the mapping (e.g. parametric function approximating the beam response, or gain/angle table, beamwidth, intersection point of multiple beams (angle, RSRP)intersection point) * Other options are not precluded * In either option, the gNB beam/antenna information can optionally be provided to the UE by the LMF for UE-based DL-AoD |

The options were discussed in [1][2][3][4][6][7][9][10][13][14][18][19][21]. The options are supported as follow:

* Option 1 is proposed in [1][3][4][6][9][13][18]
* Option 2 is proposed in [2][3][7][10][14][19][21]
* Note:
  + [3] mention that both option could be supported for different cases.
  + [21] proposes to support option 2 via assistance data for UE based positioning, and without specification (i.e. via O&M) for UE assisted positioning.

Since the two option can be seen as complementing each other, it is proposed to discuss them separately.

|  |  |
| --- | --- |
| Source | Proposal |
| [1] | ***Proposal 7: Support to reuse the existing boresight direction to assist LMF/UE to emulate the beam response for Option 1 DFT-based angle calculation enhancement.***   * ***The boresight ZoD/AoD information should be based on DFT precoder without considering the spatial shaping of the antenna element radiation pattern.*** |
| [2] | ***Proposal 5:*** *At least for UE-based DL-AOD, a mapping of angle and beam gains for each of the PRS resources can be provided to UE, where the angle is restricted to an expected uncertainty window provided by the expected DL-AoD/ZoD value and uncertainty (of the expected DL-AoD/ZoD value) range(s).* |
| [3] | * ***To decide whether to support Non-DFT-based beams information reporting before selecting one or more options from the previous agreement.*** * ***Support at least the following (option 1 in previous agreement) for the beam/antenna information to be optionally provided to the LMF by the gNB:***   + ***Option 1: the gNB reports the antenna configuration including at least the following parameter:***     - * ***the number of antenna elements (vertical and horizontal)***       * ***antenna spacing dh and dv***       * ***(optionally) Antenna Element pattern Information, such as omnidirectional or directional***   + ***The antenna configuration is the actually used antenna configuration for the DL-PRS Resources in a TRP/ or an ARP.*** * ***Support option 2 in previous agreement for the Non-DFT-based beam/antenna information to be optionally provided to the LMF by the gNB.*** * ***For Non-DFT-based beam/antenna information, support the following options:***   + ***Provide the typical parameter of beams (such as intersection point of multiple beams , beamwidth) for UE-A and UE-B DL-AoD.***   + ***Provide mapping table only for UE-A DL-AoD.*** |
| [4] | **Proposal 7: For UE-A DL-AoD positioning: support gNB to report the TX antenna configuration (e.g., antenna codebook configuration, number of elements, and antenna pattern) and TX beam configuration (e.g. beamwidth and gain). For UE-B DL-AoD positioning: gNB sends this information to the UE.** |
| [6] | ***Proposal 5: NR Rel-17 should support a gNB to report the transmission characteristics of a TRP beam to LMF, including:***   * ***The number of antenna elements (vertical and horizontal)*** * ***Antenna spacing dh and dv*** * ***For DFT-based beams, precoder information for each PRS resource (oversampling factor of the DFT-based beams)*** * ***Antenna element pattern information*** |
| [7] | **Proposal 3**: Support TRPs to optionally report multiple directions per DL PRS resource with each direction being associated with a power value relative to the boresight power for that resource.  **Proposal 4**: Include additional assistance data for UE based positioning, including TRP polarization and geometry. |
| [9] | ***Proposal 1: For beam/antenna information provided to LMF, do not support to select both Option 1 and Option 2.***  ***Proposal 2: Support Option 1 for the TRP to provide the assist information to the LMF:***   * ***In addition to the antenna configuration information, the TRP provides the precoder applied on each DL PRS resource.*** |
| [10] | ***Proposal 1: Support Option 2: Quantized version of the relative Power/Angle response per PRS resource per TRP***   * ***Opt. 2A: Provide the relative power-level(s) for a configurable uniformly sampled angular window in azimuth and zenith with respect to the boresight direction of each PRS resource***   + ***E.g., For a window of [-60,60] degrees and [-30,30] degrees in azimuth and zenith dimensions respectively with a step size of 1 dB, provide the relative power-level.*** * ***Opt. 2B: Provide the angle(s) that a relative power-level is valid from a configurable power-level set.***    + ***E.g., (Azimuth, Zenith) angles for the [-1, -3, -5, -6, -9, -10, -12, -15, -20] dB relative power-levels***   ***Proposal 2: Introduce more than one levels of quantization for the beam information to trade-off beam representation accuracy and overhead.***  ***Proposal 3: Reuse the associated-dl-PRS-ID as a way of signaling that 2 TRPs have the same beam information and reduce the overhead of sending repetitive beam patterns across TRPs.*** |
| [13] | * **The beam/antenna information can be optionally reported by the gNB to LMF including the following parameters:**   + **The total number of antenna panels for horizontal and vertical dimensions – *Ng* and *Mg***   + **The distance spacing between the antenna panels in horizontal and vertical dimensions – *dg*,*H* and *dg*,*V***   + **The total number of antenna elements within the antenna panel for horizontal and vertical dimensions – *Np* and *Mp***   + **The distance spacing between the antenna elements within the antenna panel for horizontal and vertical dimensions – *dH* and *dV***   + **The signaling that the angular DL PRS boresight spatial directions correspond to the DFT-based pre-coded beams:**     - **The LMF may request the gNB for DL PRS Resource transmission using DFT pre-coded beams with the specific spatial directions defined by the set of the azimuth and zenith angles (*φn*, *θn*)**   + **Antenna element pattern information defined in the gain/angle table as shown in Table I, where antenna gain is represented as a function of the azimuth and zenith angles**     - **The granularity of the azimuth and zenith angles report can be set up equal to 1 [deg] or 0.1 [deg]**   + **The gNB beam/antenna information can optionally be provided to the UE by the LMF for UE-based DL-AOD:**     - **A UE may request the LMF for DL PRS Resource transmission using DFT pre-coded beams with the specific spatial directions defined by the set of the azimuth and zenith angles (*φn*, *θn*)** |
| [14] | **Proposal 2: Support Option 2 (the gNB reports a mapping of angle and beam gains for each of the PRS resources)** |
| [18] | *Proposal 3: Prefer Option 1 for UE-B DL AoD positioning for the beam/antenna information provided by gNB.* |
| [19] | **Proposal 2: Support gNB to LMF reporting of information on the mapping of angle and beam gains for each of the PRS resources (Option 2). The information includes:**   * **A gain level for the reported main lobe and/or the side lobe levels.** * **A relative gain between the reported main lobe level and the side lobe levels.** |
| [21] | **Proposal 5 The LMF should be provided information of beams associated with PRS Resources over O&M. This can be done without specification impact.**  **Proposal 6 For UE based, the LMF can forward the information of beams associated with PRS resource in the form of a mapping of angle and beams gains for each of the PRS resources (option 2).** |

#### Proposal 4.1 (high priority proposal)

#### First round of discussion

**Proposal 4.1:**

**For the beam/antenna information to be optionally provided to the LMF by the gnodeB, the following is supported:**

* **the gNB can report the antenna configuration including one or more of the following parameters:**
  + **the number of antenna elements (vertical and horizontal)**
  + **antenna spacing dh and dv**
  + **PRS boresight direction**
  + **FFS: For DFT-based beams, precoder information for each PRS resource**
    - **Check whether the already reported** **boresight directions are sufficient, or whether more information is needed**
  + **FFS: Antenna Element pattern Information**
    - **FFS: Details**
  + **FFS: If additional information about panel/orientation is needed**
* **the gNB beam/antenna information can optionally be provided to the UE by the LMF for UE-based DL-AoD**

Companies are encouraged to provide comments in the table below.

**Proposal 4.1**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| vivo | Suggest to remove the first FFS since DFT beam index and boresight directions are equivalent based following formula. So, already reported boresight directions are sufficient for DFT-based beams.   |  |  | | --- | --- | | , | (3) | |
| Qualcomm | Highest priority to progress on this Aspect #4.  Prefer to have a solution that works across a variety of TRP implementations, i.e. Proposal 4.2.  Proposal 4.1 could work for DFT beams only, but in many scenarios of interest, such beams are not being used. We need to have generic solutiosn that will work in a variety of scenarios (indoor, outdoor, FR1, FR2, etc). |
| ZTE | Okay with the proposal. |
| Intel | We also think that this is a high priority. We support the proposal 4.1 and think that reporting of the boresight directions is sufficient.  As for proposal 4.2, we believe that it would be more difficult to support, since gNB may not have the information on the measured antenna pattern at all. In that case the reporting of antenna parameters is much more feasible. |
| Huawei/HiSilicon | We do not need any of the FFS, and the boresight direction is already supported. |
| CATT | We are fine with the proposal. |

#### Proposal 4.2 (high priority proposal)

#### First round of discussion

**Proposal 4.2:**

**For the beam/antenna information to be optionally provided to the LMF by the gnodeB, the following is supported:**

**The gNB reports quantized version of the relative Power/Angle response per PRS resource per TRP**

* **FFS: support of multiple levels of quantization**
* **FFS: how the report is constructed.**
  + **Opt. A: Provide the relative power-level(s) for a configurable uniformly sampled angular window in azimuth and zenith with respect to the boresight direction of each PRS resource**
  + **E.g., For a window of [-60,60] degrees and [-30,30] degrees in azimuth and zenith dimensions respectively with a step size of 1 dB, provide the relative power-level.**
  + **Opt. B: Provide the angle(s) that a relative power-level is valid from a configurable power-level set.**
  + **E.g., (Azimuth, Zenith) angles for the [-1, -3, -5, -6, -9, -10, -12, -15, -20] dB relative power-levels**
  + **Other options are not precluded.**
* **FFS: overhead reduction mechanisms, including reusing of associated-dl-PRS-ID as a way of signaling that 2 TRPs have the same beam information**

Companies are encouraged to provide comments in the table below.

**Proposal 4.2**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| vivo | Suggest to add option C as follows  **Opt. C: Provide the** **beamwidth for the fixed relative power level**   * + **E.g., beamwidth for the -3 dB relative power-levels** |
| Qualcomm | Highest priority proposal. Support of this proposal.  This solution is more generic, applies across a variety of TRP implementations and can be easily specified.  To vivo: Option C is a subset of Option B for a relative power level of {-3 dB} only. |
| ZTE | Opt.A. We prefer FFS the angular window |
| Intel | We prefer option 1 (proposal 4.1), since we think it is more feasible to support it. But we are OK to support option 2 (proposal 4.2) as well. |
| Fraunhofer | Support |
| Huawei, HiSilicon | Not sure why Power/Angle response per resource is used.  To our understanding, Power/Resource per Angle is more appropriate. It matches DL-AOD reporting, where the UE only reports multiple pair of Power/Resource, and LMF is targeted to find the best match in the angle domain angle.  We are afrait the current mechanism would require the same normalization of radiated power across all PRS resource and angles, which is not necessary, and rediation pattern may also reveal the antenna element radiation pattern.  For Option A, not clear why we need uniformly sampled angle, which is too restrictive.  For Option B, it is not possible to measure the –XdB rediation circle in the 3D space.  If such value is obtained through real test, network would need to ensure the same distance between TRP and testing point so that there is no pathloss impact.  If such value is obtained through emulation, the antenna radiation pattern needs to be considered.  So to our understanding, if the rediation pattern is used, we should go with the following alternative:  **The gNB reports quantized version of the relative Power between PRS resources per angle per TRP.**   * **For each angle, at least two PRS resources are reported.** * **The relative power is defined with respect to the peak power in the angle** |
| CATT | We think it is important to discuss and determine the formats of beam/antenna information provided to the LMF by the gnodeB, but we think RAN3 also should be involved and an LS is needed after we had the conclusion.  We prefer the updated Proposal 4.2 as follows,  **Updated Proposal 4.2:**  **For the beam/antenna information to be optionally provided to the LMF by the gnodeB, the following is supported:**  **The gNB reports quantized version of the relative Power/Angle response per PRS resource per TRP**   * **FFS: support of multiple levels of quantization** * **FFS: how the report is constructed.**   + **Opt. A: Provide the relative power-level(s) for a configurable uniformly sampled angular window in azimuth and zenith with respect to the boresight direction of each PRS resource**   + **E.g., For a window of [-60,60] degrees and [-30,30] degrees in azimuth and zenith dimensions respectively with a step size of 1 dB, provide the relative power-level.**   + **Opt. B: Provide the angle(s) that a relative power-level is valid from a configurable power-level set.**   + **E.g., (Azimuth, Zenith) angles for the [-1, -3, -5, -6, -9, -10, -12, -15, -20] dB relative power-levels**   + **Other options are not precluded.** * **FFS: overhead reduction mechanisms, including reusing of associated-dl-PRS-ID as a way of signaling that 2 TRPs have the same beam information**   **Send LS to RAN3 informing them of the agreement** |

### Aspect #5 AoD uncertainty window

#### Summary and FL proposal

In RAN1#104b-e, the following agreement was reached:

|  |
| --- |
| Agreement:   * For the purpose of both UE-B and UE-A DL-AoD, and with regards to the support of AOD measurements with an expected uncertainty window, study further whether to support at most one of the following options:   + Option 1: Indication of expected DL-AoD/ZoD value and uncertainty (of the expected DL-AoD/ZoD value) range(s) is signaled by the LMF to the UE     - Single Expected DL-AoD/ZoD and uncertainty (of the expected DL-AoD/ZoD value) range(s) can be provided to the UE for each [TRP]   + Option 2: Indication of expected DL-AoA/ZoA value and uncertainty (of the expected DL-AoA/ZoA value) range(s) is signaled by the LMF to the UE     - Single Expected DL-AoA/ZoA and uncertainty (of the expected DL-AoA/ZoA value) range(s) can be provided to the UE for each [TRP]   + Option 3: Indication of expected AoD/ZoD or AoA/ZoA value and uncertainty is not introduced.   + FFS: details of signaling * FFS: Applicability of this agreement to other Positioning methods |

Proposals in provide updated view on the issue. As in RAN1#105e, there is a split of support between the options, with contribution also mentioning not introducing the expected AoA/AoD value and uncertainty, or instead using the signalling of PRS IDs corresponding to the window:

* Option 1 is supported by [2][3][5][10][15][18]
  + use of PRS ID(s) to cover the expected value and uncertainty is mentioned in [21]
* Option 2 is supported by [1][7]
* Use of a PRS as reference direction is mentioned in [6], and use of PRS ID(s) to cover the expected and uncertainty is mentioned in [21]
* [9] does not support introducing the feature

|  |  |
| --- | --- |
| Source | Proposal |
| [1] | ***Proposal 8: Support indication of expected DL-AoA/ZoA value and uncertainty (of the expected DL-AoA/ZoA value) range(s) is signaled by the LMF to the UE***   * ***Single Expected DL-AoA/ZoA and uncertainty (of the expected DL-AoA/ZoA value) range(s) can be provided to the UE for each [TRP]*** * ***Note: This is also applicable to DL-TDOA and Multi-RTT methods.*** |
| [2] | ***Proposal 4:*** *For the purpose of both UE-B and UE-A DL-AoD, and with regards to the support of AOD measurements with an expected uncertainty window, which includes,*   * *Option 1: Indication of expected DL-AoD/ZoD value and uncertainty (of the expected DL-AoD/ZoD value) range(s) is signaled by the LMF to the UE* * *DL PRS resources transmitted from a single TRP (or a single ARP if configured) are associated with a single value of Expected DL-AoD/ZoD and uncertainty (of the expected DL-AoD/ZoD value).*   *Note: The expected uncertainty window is defined by the LOS direction between a TRP (or a ARP if configured) and a UE.* |
| [3] | **Proposal 5**   * ***Support to provide the boresight angle of the PRS resource first for selecting PRS resources by expected DL-AoD/ZoD.***   **Proposal 6**   * ***Support intention 1 first for providing an Expected DL-AoD/ZoD and uncertainty information to indicate a subset of DL PRSs expected to be measured in an angle range.***   ***FL note: intention 1 refers to using expected AoD to select the PRS resources to be measured.***  **Proposal 7**   * ***The validity of the expected DL-AoD (for example: one-shot information) may need to be considered since the expected DL-AoD will easily be changed with the UE movement.***   **Proposal 8**   * ***If expected AoD is supported in Rel-17 positioning, adopt the expected AoD as in the following table.***  |  |  |  | | --- | --- | --- | |  | ***Expected RSTD*** | ***Expected AoD*** | | Parent IE | *NR-DL-PRS-AssistanceData* | *NR-DL-PRS-AssistanceData-r17,or RequestLocationInformation* | | Value range | +/- 500 us | 0-360 degree | | Cast Type | Unicast and broadcast | Unicast | | Update Rate | Cell-specific information and Update with the *NR-DL-PRS-AssistanceData* | One-shot UE-specific information and Update when transmitted *RequestLocationInformation* | | Present | Mandatory present | Optional present |   ***Proposal 9***   * ***Expected DL-AoD is provided to the UE for each TRP.*** |
| [5] | ***Proposal 6: For the purpose of both UE based and UE assisted DL-AoD, the LMF can provide the UEwith the expected DL-AoD/ZoD value and uncertainty (of the expected DL-AoD/ZoD value) ranges if these can be accurately determined.*** |
| [6] | ***Proposal 3: The reference direction of the expected DL-AoD/ZoD or DL-AoA/ZoA, which can be the resource ID(s) of DL/UL reference signals or SSB index, should be indicated to UE.*** |
| [7] | **Proposal 9**: Support Option 2 - Indication of expected DL-AoA/ZoA value and uncertainty (of the expected DL-AoA/ZoA value) range(s) is signaled by the LMF to the UE.    **Proposal 10**: For UE-based mode, support option 1: indication of expected DL-AoD/ZoD value and uncertainty (of the expected DL-AoD/ZoD value) range(s) is signaled by the LMF to the UE.  **Proposal 11**: Support of indication of expected AoD/ZoD value and uncertainty (of the expected AoD/ZoD value) range(s) is signaled by the LMF to gNBs/TRPs in on-demand PRS framework. |
| [9] | Proposal 4: On uncertainty window for DL-AoD, support Option 3, i..e, do not introduce expected AoD/ZoD or AoA/ZoA and uncertainty |
| [10] | ***Proposal 5: With regards to expected Angle of Departure, support Option 1 with the following signaling details:***   * ***Expected azimuth angle of departure as (φAOD - ΔφAOD/2, φAOD + ΔφAOD/2)***   + ***φAOD - expected azimuth angle of departure, ΔφAOD – uncertainty range for expected azimuth angle of departure*** * ***Expected zenith angle of departure as (θAOD - ΔθAOD/2, θAOD + ΔθAOD/2)***   + ***θAOD - expected zenith angle of departure ΔθAOD – uncertainty range for expected zenith angle of departure*** |
| [15] | **Proposal 3**: For DL-AoD technique, support DL-AoD/ZoD assistance information (expected and uncertainty window), signaled from LMF to the UE for each TRP measurement. |
| [17] | **Proposal 1:**   * **Support one of the following options**   + **Option 1: Indication of expected DL-AoD/ZoD value and uncertainty (of the expected DL-AoD/ZoD value) range(s) is signaled by the LMF to the UE**   + **Option 2: Indication of expected DL-AoA/ZoA value and uncertainty (of the expected DL-AoA/ZoA value) range(s) is signaled by the LMF to the UE** |
| [18] | *Proposal 2: Slightly prefer Option 1 for LoS path.*   * *Indication of expected DL-AoD/ZoD value and uncertainty (of the expected DL-AoD/ZoD value) range(s) is signaled by the LMF to the UE.* |
| [21] | Proposal 11 LMF can optionally signal to the UE an indication that consist of a list of IDs of DL PRS Resources associated to beams that are within a DL-AOD uncertainty region. |

Based on the discussion, the proposal from RAN1#105e is amended to include the proposal of [21] as an alternative to the AoD/ZoD uncertainty. As it is now time to converge on the issue, the proposal is reworded to support both options, with the understanding that the discussion will make the proposal evolve (option 3 being covered if the proposal is not supported).

**Proposal 5.1**

**For the purpose of both UE-B and UE-A DL-AoD, and with regards to the support of AOD measurements with an expected uncertainty window, the following is supported**

* **Indication of expected DL-AoD/ZoD value and uncertainty (of the expected DL-AoD/ZoD value) range(s) is signaled by the LMF to the UE**
  + - **FFS: how to signal value and range:**
      * **Option A: Single Expected DL-AoD/ZoD and uncertainty (of the expected DL-AoD/ZoD value) range(s) can be provided to the UE for each [TRP]**
      * **Option B: a list of PRS indices corresponding to the uncertainty, with one PRS index identifying the expected value, if any.**
* **Indication of expected DL-AoA/ZoA value and uncertainty (of the expected DL-AoA/ZoA value) range(s) is signaled by the LMF to the UE** 
  + - **Single Expected DL-AoA/ZoA and uncertainty (of the expected DL-AoA/ZoA value) range(s) can be provided to the UE for each [TRP]**
* **FFS: details of signaling**
* **FFS: Applicability to other Positioning methods**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Support only Option 1. This feauture is useful for the UE to focus its efforts to a limited set of beams, and have some prior information about the AoD. It is unclear why it has created so much controversy. |
| ZTE | Option 1. We think this is a high priority proposal. |
| Intel | Support option 2, i.e. DL-AOA/ZOA value and uncertainty range reporting at least for the PRU with the known antenna orientation in space. |
| Huawei, HiSilicon | Option 2. It is direct from UE Rx perspective. |
| CATT | Support either Option 1 or Option 2, but not the both options. |

### Aspect #6 2-step beam refinement

#### Summary and FL proposal

RAN1#105e was the first meeting where 2-step beam refinement/sweeping was discussed. In [1]

[2][4][5][6][7][9][10][11][12][19][20], the understanding of what a 2-step procedure would include was discussed by companies. The following was identified:

* [1][5] uses the 2-step procedure for coupling a PRS “normal beam” to a second “differential beam”
* [4][10][11][] proposes that a 2 step procedure should be coupled to on demand PRS
* [6][7][9][12][19][20] discuss association/refinement between PRS in two separate resource sets in the same TRP
  + - [7] further details that the second resource set in the 2 step procedure is the one used for reporting.
* [2] proposes to deprioritize the issue

Since the discussion is relatively new, a good first step is to clarify whether the discussion should be part of the on-demand PRS agenda. If so, we can close the discussion in this AI. If the discussion continues as part of the AoD agenda, since a lot of pressing issues need to be closed, it is proposed to downprioritize the issue.

|  |  |
| --- | --- |
| Source | Proposal |
| [1] | ***Proposal 5: Support 2-stage PRS beam sweeping for differential beam where the first PRS resource set corresponds to the normal beam and the second PRS resource set corresponds to the differential beam.***  ***Proposal 6: No need to discuss reconfiguration of a single resource set to enable 2-stage beam sweeping.*** |
| [2] | ***Proposal 9:*** *Don’t support or at least* *deprioritize corresponding enhancements on two-stage PRS beam sweeping.* |
| [4] | **Proposal 2: Support LMF to assist gNBs to facilitate the two-stage beam sweeping operation. It can be performed such as LMF configures sweeping beam directly by on-demand PRS, or LMF sent assistance information to gNB (e.g., the expected AoD range, beam width).**    **Proposal 3: Support two-stage beam sweeping for DL-AOD and DL-TDOA positioning** |
| [5] | ***Proposal 2: Support differential beamforming technique for DL-AOD positioning methods.***  ***Proposal 3: In the aspects of PRS resource configuration, DL transmission beam indication and UE measurement and report needs to be included in order to support differential beamforming technique for DL-AOD positioning methods.*** |
| [6] | ***Proposal 4: For two-stage PRS beam sweeping, the dynamic association between DL PRS resources belonging to two DL PRS resource sets of the same TRP should be supported.*** |
| [7] | **Proposal 6**: Support association between resources belonging to two DL PRS resource sets (at the same TRP) to facilitate support of two stage beam sweeping.    **Proposal 7:** In two-stage beam sweeping DL-AoD, the positioning report should be generated only based on the second-stage PRSs.    **Proposal 8:** Support and study on-demand PRS framework for two-stage PRS beam sweeping. |
| [9] | Proposal 7: Support UE-specific beam refinement on DL PRS resource in On-demand DL PRS.  Proposal 8: For beam refinement on DL PRS:   * Support to provide DL PRS beam information (NR-DL-PRS-BeamInfo) to the UE for DL-AoD methods. * Do not introduce additional association between PRS resources for beam operation. |
| [10] | ***Proposal 8: With regards to two-stage beam sweeping, treat it within the on-demand PRS framework and support the UE to be able to report one or more desired beam directions / PRS resources / PRS resource sets from the already configured AD or the potential on-demand PRS configurations.*** |
| [11] | **Proposal 2: For both UE-based and UE-assisted DL methods, support a two-stage DL PRS beam sweeping, and the discussion can be put under the on-demand DL PRS subagenda.** |
| [12] | ***Proposal 4:***   * Regarding 2-stage PRS beam sweeping, RAN1 should consider the following procedure for 2-stage beam reporting:   + In case of the first PRS resource set, it can be composed of multiple PRS resources and they are associated with wide beams.   + And then, the multiple PRS resources that are in the second PRS resource set can be associated with narrow beams. LMF can configure associated PRS resources based on the measurement report in the first step. |
| [19] | **Proposal 3: For improving device efficiency, support a procedure that enables the device to activate or deactivate measurements on DL-PRS resources in the second stage depending on the received associated DL PRS resources in the first stage.** |
| [20] | ***Proposal 4: Association between resources belonging to two DL PRS resource sets of the same TRP can be enabled by a grouping ID and can be signalled in the assistance data.***  ***Proposal 5: Two-stage PRS beam sweeping can be enabled by the on-demand PRS mechanism.*** |

**Proposal 6.1:**

**The discussion on 2-step beam refinement is moved under the on-demand PRS agenda**

#### First round of discussion

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Support |
| ZTE | Support |
| CATT | We prefer to sitll discuss 2-step beam refinement in AI 8.5.3, since this issue is not only related to on-demand PRS, but also the normal DL PRS. |

## Other aspects

|  |  |
| --- | --- |
| Source | Proposal |
| [2] | * ***Proposal 6****: To extend the application scope of DL PRS Rx beam index, when the UE reports DL PRS-RSRP measurements from* ***DL PRS resource sets associated with the same positioning frequency layer and the same TRP****, the UE may indicate which DL PRS-RSRP measurements associated with the same higher layer parameter DL PRS Rx beam index have been performed using the same spatial domain filter for reception.* |
| [2] | ***Proposal 7:*** *To address the issue on DL PRS-RSRP measurements reporting for DL-AOD when different DL PRS resource sets are configured with different transmission powers, considering at least one of the following options,*   * *Option 1: All DL PRS resource sets associated the same TRP should be configured with the same transmission power.* * *Option 2: The additional DL PRS-RSRP measurement can be less than, equal to or larger than zero according to the mapping table designed in TS 38.133 of Table 10.1.24.3.2-2.* * *Option 3: Supporting UE to report more than one absolute DL PRS-RSRP measurements per TRP.* * *Option 4: Supporting UE to report scaling RSRP.* |
| [2] | ***Proposal 8****: The source reference signal for QCL of a target DL PRS resource can be,*   * *A SSB: the SSB and the target DL PRS resource are from the same band. Meanwhile, the associated Physical Cell ID of the SSB should be the same as corresponding information associated the target DL PRS resource.* * *A source DL PRS resource: the source DL PRS resource and the target DL PRS resource are from the same positioning frequency layer (or the same band) and the same TRP.* |
| [5] | ***Proposal 7: For two-stage PRS beam sweeping, support that one PRS resource set corresponding to wide beams with each PRS resource is associated with the PRS resources in another PRS resource set corresponding to narrow beams.*** |
| [7] | **Proposal 13:** RAN1 to specify support for enabling a PRU to support configuration by the network to help with beam offset estimation, among other parameters. In particular, RAN1 should investigate methods and signaling required to enable the selected reference device to ability of reference device to determine beam offset errors are present. |
| [18] | *Proposal 4: Estimate the angle error by a reference node whose accurate location is known.* |

#### Comments

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| --- | --- |
| **Company** | **Comment** |
| ZTE | We encourage interested companies to further consider the proposals 6,7,8 from ZTE, which includes some problems in Rel-16 that may impact the DL-AOD positioning . |

1. Conclusion

**TBD**

1. References
2. R1-2106451, Enhancement for DL AoD positioning, Huawei, HiSilicon
3. R1-2106551, Accuracy improvement for DL-AoD positioning solutions, ZTE
4. R1-2106597, Discussion on potential enhancements for DL-AoD method, vivo
5. R1-2106811, Considerations on DL-AoD enhancements, Sony
6. R1-2106890, Discussion on accuracy improvements for DL-AoD positioning solutions, Samsung
7. R1-2106973, Discussion on enhancements for DL-AoD positioning method, CATT
8. R1-2107059, Views on enhancing DL AoD, Nokia, Nokia Shanghai Bell
9. R1-2107169, Discussion on enhancements for DL-AoD positioning, CAICT
10. R1-2107215, Enhancements for DL-AoD positioning, OPPO
11. R1-2107347, Potential Enhancements on DL-AoD positioning, Qualcomm Incorporated
12. R1-2107405, Discussion on DL-AoD enhancements, CMCC
13. R1-2107544, Discussion on accuracy improvement for DL-AoD positioning, LG Electronics
14. R1-2107592, DL-AoD Enhancements for Precise NR Positioning, Intel Corporation
15. R1-2107646, Discussion on enhancements for DL-AoD positioning solutions, InterDigital, Inc.
16. R1-2107742, Positioning Accuracy enhancements for DL-AoD, Apple
17. R1-2107823, Accuracy enhancement for DL-AOD technique, MediaTek Inc.
18. R1-2107860, Discussion on DL-AoD positioning enhancements, NTT DOCOMO, INC.
19. R1-2107922, Accuracy improvements for DL-AoD positioning solutions, Xiaomi
20. R1-2108103, DL-AoD positioning enhancements, Fraunhofer IIS, Fraunhofer HHI
21. R1-2108143, Discussion on DL-AoD Positioning Enhancements, Lenovo, Motorola Mobility
22. R1-2108166, Enhancements of DL-AoD positioning solutions, Ericsson
23. R1-2108174, Discussion on enhancements for DL-AoD positioning, CEWiT