3GPP TSG-RAN WG1 Meeting #107 -e R1-21NNNN

e-Meeting, November 11th – 19th, 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:

[107-e-NR-ePos-03] Email discussion/approval on accuracy improvements for DL-AoD positioning solutions with checkpoints for agreements on November 15 and 19 – Florent (Ericsson)

The FL proposals are based on submission to AI 8.5.3 [1-21] and treat the following aspects:

* Aspect #1 reporting of first path RSRP
	+ TOA reporting
	+ Normalization of the PRS RSRP
* Aspect #2 extension of number of reported RSRP measurements
	+ Value for max number of reported measurement
	+ RX beam considerations
* Aspect #3 Adjacent beam identification in AD and reporting by the UE
	+ LMF Request of a subset of PRS measurement related to a PRS measurement
	+ Indication of the subsets
	+ Prioritization of measurements
	+ Signalling of boresight information
* Aspect #4 Support of additional gnodeB beam information signalling
	+ Signalling of the beam information, representation of beam angle and power
* Aspect #5 AoD uncertainty window
* Aspect#6 2-step beam refinement

1. Aspects for discussion

##  Main discussion topics

###  Aspect #1 reporting of first arrival path

#### Summary

During RAN1#106b-e, the following agreement was reached:

|  |
| --- |
| Agreement:The measured path DL PRS RSRP for ith path delay is defined as the power of the received DL PRS signal configured for the measurement at the ith path delay of the channel response, and* path DL PRS RSRP for 1st path delay is the power corresponding to the first detected path
* FFS: Whether the path RSRP measurement is normalized with PRS RSRP.
* FFS: Whether the definition of the ith path delay (other than i=1) is required.
* Note: UE may choose to use a time window to compute path DL PRS RSRP by UE implementation (there is no impact to specifications managed by RAN1 for this)
* Note: This does not imply that the path delay has to be reported in DL-AoD positioning
* Send LS to RAN4 to check the details of the definition and feedback if they identify any update is necessary
 |

The contributions for RAN1#107e are centered on resolving the two FFS of the agreement:

* Whether the path RSRP measurement is normalized with PRS RSRP. [1] [2] [4] [5] [7] [8] [9] [12] [14] [13] [18] [19] [20].
* Whether the definition of the ith path delay (other than i=1) is required. [2] [6] [7] [12] [15] [19] [20].

Proposals on time of arrival reporting are discussed in [1][3][5][6][8][20].

Additionally, receiver diversity [1], use of thresholds [15] or indicators for reporting of path RSRP [12] are also discussed.

#### Proposal 1.1 (reporting of further information for path RSRP)

####  Summary of proposals

The proposal regarding further reporting for the DL PRS path RSRP mostly discuss whether there is a need for further definition of the ith path:

* [2][7][20] propose not to define the ith path delay further, while [12] propose to extend the first path definition.
* [15] thinks the definition for the ith path is required and proposes a time window
* [6],[19] suggest to transfer the issue to the NLOS agenda item.

|  |  |
| --- | --- |
| Source | Proposal |
| [2] | ***Proposal 2:*** *There is no need to have new definition for the ith path delay since the field descriptions in TS 37.355 have already specified how to report timings of additional paths.* |
| [6] | **Proposal 2**: Regarding whether to define the ith path delay (other than i=1), we would propose to follow discussion result about the similar issue in AI 8.5.5 (LoS/NLoS). |
| [7] | **Proposal 1: The current definition of measured path DL PRS RSRP for ith path delay is sufficient. Specific definition of other path(s) than the first path (other than i=1) is not required.** |
| [12] | ***Proposal 1: An indicator of whether the report for PRS RSRP includes all the paths or the first arrival path only is supported.******Proposal 6: The ith path is determined using the same principle as that for determining first path.***  |
| [15] | ***Proposal 4:**** Definition of the ith path delay (other than i=1) is required.
* ith path delay can be defined as a path delay within a time window to compute path DL PRS RSRP which is not overlapped with other time window to compute path DL PRS RSRP.
 |
| [19] | ***Proposal 2: Consider the ith path delay, aside from i=1, in the path RSRP definition, subject to the outcome of related discussions in AI8.5.5.*** |
| [20] | **Proposal 3: The definition of the i:th path delay for path PRS RSRP is not required.** **Proposal 4 Include DL PRS-RSRPP of the first path in NR DL-AoD Location Information alongside the existing DL PRS-RSRP measurement. Specifically, add it to the NR-DL-AoD-MeasElement IE and the NR-DL-AoD-AdditionalMeasurementElement IE****Proposal 6 Include additional paths in the DL-AOD measurement report. For each additional path the DL PRS-RSRPP and the associated timing measurement should be reported.****Proposal 7 The nr-AdditionalPathList-r16 IE is included as a Rel. 17 addition at the top level of the NR-DL-AoD-MeasElement-r16 IE as well as in the NR-DL-AoD-AdditionalMeasurements-r16 IE.****Proposal 8 DL PRS-RSRPP is included as a Rel. 17 addition for each additional path in the nr-AdditionalPathList-r16 IE.** |
|  |  |

####  First round of discussion

Based on the majority of proposal, it is propose to conclude not to define further the ith path day in this agenda item. We can leave the discussion up to other agenda items if it is required there.

 **Proposal 1.1 (for conclusion): The current definition of measured path DL PRS RSRP for ith path delay is sufficient and will not be discussed further in AI 8.5.3**

* **Note: discussion in other agenda items, if necessary, is not precluded.**

Companies are encouraged to provide comments in the table below.

**Proposal 1.1**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Support. No need to discuss again.  |
| Nokia/NSB | We prefer to follow the discussion result of the similar issue of AI8.5.5 (LoS/NLoS) |
| OPPO | Support the conclusion |
| InterDigital | Support |
| CATT | Support.We can only focus on path DL PRS RSRP for 1st path delay in this AI. |
| Samsung | Support |
| Huawei, HiSilicon | The receiver diversity of the definition should be addressed. Our following proposal should be discussed here, instead of being in 2.2.1.1.

|  |
| --- |
| ***Proposal 3: For path DL PRS RSRP measurement reporting, when receiver diversity is in use, the reported path DL PRS RSRP shall be corresponding to the same Rx branch associated with the reported DL PRS RSRP.*** |

The following is what is now captured in the draft CR.

|  |  |
| --- | --- |
| **Definition** | DL PRS reference signal received path power (DL PRS-RSRPP), is defined as the power of the received DL PRS signal configured for the measurement at the i-th path delay of the channel response, where DL PRS-RSRPP for 1st path delay is the power corresponding to the first detected path in time.[For frequency range 1, the reference point for the DL PRS-RSRPP shall be the antenna connector of the UE. For frequency range 2, DL PRS-RSRPP shall be measured based on the combined signal from antenna elements corresponding to a given receiver branch. For frequency range 1 and 2, if receiver diversity is in use by the UE, the reported DL PRS-RSRPP value shall not be lower than the corresponding DL PRS-RSRPP of any of the individual receiver branches.] |

**FL: added as proposal 1.4.**  |
| ZTE | Support |
| vivo | SupportWe prefer to discuss Rx branch in RAN4 |
| Lenovo, Motorola Mobility | Support |
| Fraunhofer | Support |

####  Outcome of First round of discussion (stable proposal)

Since there is no opposition to the proposal, it is suggested that proposal 1.1 can be endorsed for conclusion. It is noted that the discussion may continue in AI 8.5.5 if needed.

**Proposal 1.1 (for conclusion): The current definition of measured path DL PRS RSRP for ith path delay is sufficient and will not be discussed further in AI 8.5.3**

* **Note: discussion in other agenda items, if necessary, is not precluded.**

Should any company oppose to convert the proposal into an agreement, please comment directly in the email discussion.

#### Proposal 1.2 (normalization of the path RSRP measurement)

####  Summary of proposals

 The proposals discuss two separate issues:

* Whether the measurement definition for DL-PRS RSRPP should include PRS-RSRP normalization
	+ Proposals in support:[4][7][8] [13] [19]
	+ Proposals against: [12] [20]
* Whether the reporting of DL-PRS RSRPP should be done by inclusing relative DL-PRS-RSRPP to PRS-RSRP, reported together with DL-PRS-RSRPP.
	+ Proposal in support: [2][5] [9] [14] [18] [20]

|  |  |
| --- | --- |
| Source | Proposal |
| [1] | ***Proposal 2: If normalization is required, RAN1 can take the frequency domain averaging as the modification to the path RSRP definition.**** ***Path RSRP of ith path delay is the power (in [W]) of the linear average of the ith path delay compensated channel response of the resource elements that carry reference signals.***
 |
| [2] | ***Proposal 1:*** *The path PRS RSRP of a DL PRS resource is reported relative to the corresponding DL PRS-RSRP at least for first detected path.* |
| [4] | ***Proposal 1: Normalization of the path RSRP measurement with DL PRS RSRP could be included in the measurement definition.*** |
| [5] | Proposal 1: For path PRS RSRP measurement reporting, the UE reports the differential RSRP with reference to the RSRP of the corresponding PRS resource. |
| [7] | **Proposal 2: The path RSRP measurement is normalized with PRS RSRP.** |
| [8] | **Proposal 1*** + **The path RSRP measurement is normalized to the total DL PRS RSRP (RSRP of all paths as defined in Rel.16)**
 |
| [9] | *Proposal 5: Prefer to normalize the path PRS-RSRP with PRS RSRP for signaling overhead reduction.* |
| [12] | ***Proposal 5: The path RSRP measurement is NOT normalized with PRS RSRP.*** |
| [14] | **Proposal 1**: The UE can be requested to report path PRS RSRP together with PRS RSRP in an AOD measurement report, where path PRS RSRP is relative to the included PRS RSRP.  |
| [13] | **Proposal 1: Path RSRP measurement is normalized with PRS RSRP** |
| [18] | ***Proposal 5: Signaling details of the path RSRP report: The UE shall report the relative ratio of the power of the path over the total RSRP of the PRS resource using the following format:**** ***Maximum value is 0 dB***
* ***Minimum value: [-30] dB***
* ***Step size: [0.5] dB***
* ***The UE is expected to report the RSRP when path-RSRP is included.***
 |
| [19] | ***Proposal 1: Support inclusion of normalization as part of the definition of first path DL PRS RSRP with respect to the total received DL PRS RSRP (as defined in Rel-16).*** |
| [20] | **Proposal 1: Define the path DL PRS RSRP as the absolute power, without normalization.****Proposal 2: In measurement reports, normalize path DL PRS RSRP by DL PRS RSRP and include DL PRS RSRP in the report.** |

####  First round of discussion

In order to clarify the situation, it is propose to start with discussing whether normalization applies to the DL PRS RSRPP definition in 38.215, the reported value (which is then reported along with PRS RSRP), both or neither.

**Proposal 1.2: for the DL-PRS RSRPP, regarding how normalization is applied:**

* **Alt1: normalization with DL PRS RSRP is applied to the measurement definition and to in the measurement report of DL PRS RSRPP.**
* **Alt2: normalization with DL PRS RSRP is applied only in the measurement report of DL PRS RSRPP. The LMF reconstruct the defined measurement for DL PRS RSRPP from the reported DL-PRS RSRP and(normalized) DL PRS RSRPP.**
* **Alt3: no normalization is applied.**

Companies are encouraged to provide comments in the table below.

**Proposal 1.2**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Alt. 2 is our preference. We prefer not to start touching the definition again, and if we start discussing Alt. 1 companies will want to do more changes. We need to close the issues.  |
| OPPO | Support Alt.2. The normalization shall not be applied to definition and we prefer not to reopen the definition again too.  |
| InterDigital | Ok with Alt. 2. |
| CATT | Support.We prefer Alt.1. In our opinion, the ratio of the receiving power of the first arriving path to the total PRS-PRSP with Rel-16 definition reflects the LOS path possibility of a PRS resource. It is beneficial to be used by LMF for improving the accuracy of UE positioning calculation. Therefore, normalization of the path RSRP measurement with DL PRS RSRP could be supported. |
| Samsung | We prefer Alt. 2 |
| Huawei, HiSilicon | One thing to clarify: When we say normalization, interpretation 1 is the PRS-RSRPP is expressed in [dBmW] in the same order of magnitude as PRS-RSRP, and interpretation 2 is the about report relative power of PRS-RSRPP with respect to PRS-RSRP, e.g. expressed in [dB] or linear value (<1).It appears that companies supporting Alt.2 is using interpretation 2.May I have clear understanding what we are addressing with this proposal?To our understanding, whether the power is normalized, and which reference is used for relative power reporting are separate issues, and should be discussed by RAN4. |
| ZTE | Alt.2. To our understanding, this proposal is to discuss how to report first path RSRP, which should reported relative to corresponding DL PRS-SRSP. |
| vivo | Alt 2 with modification. That is, we think the second sentence of Alt 2 can be removed since LMF behavior doesn’t need to be specified.And we prefer the normalization is{10\*log10( PRS-RSRPP/ PRS-RSRP ) |
| Intel  | Alt 2 |
| Lenovo, Motorola Mobility | Prefer Alt. 1 but ok to go for Alt.2 as well |
| Ericsson | OK with alt2. We could actually defer further details on the reporting to RAN2, which can decide how to optimize the report for best accuracy.  |
| Fraunhofer | We are okay with Alt2 |
| Nokia/NSB | Okay with Alt2. |

#### Proposal 1.3 (time of arrival)

####  Summary of proposals

The following proposal want to introduce time of arrival reporting for each path in AOD:

* [5][20] support reporting TOA for each path
* [6] support measurements report including TOA or RSTD
* [8][20] proposes to reuse the additional path framework
* [3] propose not to support reporting timing information.
* Additional assistance data is discussed in [15] with a proposal to include expected RSRP/path RSRP. Reporting according to a threshold is proposed in [15] and discussed in [17]
* [1] propose to either ensure that all reported resources are reportd for the same TOA, or that the RSTD between resources for the first path of each resource is reported.

|  |  |
| --- | --- |
| Source | Proposal |
| [1] | ***Proposal 1: Adopt either one to ensure that network can be informed of whether the same path is used for the reported first path PRS-RSRP values across multiple PRS resources.**** ***Alt.1 UE is expected to ensure that the first path PRS-RSRP corresponds to the same path by implementation.***
* ***Alt.2 UE shall report a reference PRS resource associated with the first path PRS-RSRP, and report the relative TOA of the first path for the remaining PRS resources that is associated with the first path PRS-RSRP***
	+ ***The relative TOA of the first path for the remaining PRS resources is defined with respect to the TOA of the first path for the reference PRS resource.***
 |
| [3] | ***Proposal 1:**** ***Only support first path RSRP reporting in DL-AoD positioning, and reporting multipath RSRP(s) are not introduced in DL-AoD.***
* ***Reporting timing information is not introduced in DL-AoD.***
 |
| [5] | Proposal 2: In DL-AoD measurement report, the UE report the time-of-arrival of each reported PRS resource or each path. |
| [6] | **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 or RSTD. |
| [8] | **Proposal 2*** + **For the DL-AOD positioning method, support introducing an additional path reporting using the following format:**
		- **For each additional path the relative time difference with respect to the first detected path, the path quality indicator, and the path RSRP values are reported**
		- **The LMF may request the maximum number of additional paths equal to *N***
			* **The maximum number of additional paths can be selected from the set *N* = {2, 4}**
 |
| [20] | **Proposal 5 The DL PRS-RSRPP is reported together with an associated timing measurement of the corresponding path.** |

####  First round of discussion

A proposal for time of arrival reporting was discussed briefly during RAN1#106b-e, without reaching consensus. Several companies mention that time information should be an RSTD relative to the initial path. It is proposed to start the discussion based on the following proposal:

 **Proposal 1.3:**

**When path PRS RSRP for an additional path (i.e. not the first path) is reported for DL AOD, an associated timing measurement of the corresponding path can also be reported.**

* **In a measurement report, the reported timing is the RSTD between the additional path and the first arriving path for the same DL-PRS resource.**

**For the first path PRS RSRP, downselect between:**

* + **Alt1: The path PRS RSRP for all reported resources in the TRP correspond to the same time of arrival**
	+ **Alt2: an RSTD between a reference PRS resource and other PRS resources in the TRP is reported for the first path measurements in the TRP .**

Companies are encouraged to provide comments in the table below.

**Proposal 1.3**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Not support. Have there been any evaluations on how this can help DL-AoD, especially when DL-TDOA can already be configured simultaneously ? A UE can support simultaneous DL-AoD and DL-TDOA (alreadu from rel-16, when a separate capability was introduced for that purpose), and all the information can be sent back to the network. |
| Nokia/NSB | The main-bullet is only for the additional path and it does not seem to include the second subullet for the first path RSRP. We suggest two separate proposals for the additional path and the first path. We are supportive of Alt2 for the first path RSRP reporting. |
| OPPO | For the 2nd bullet: we support the Alt2. |
| CATT | Support the proposal in principle, since we believe the associated timing information would be helpful for the LMF to use the path PRS RSRP information.For the first path PRS RSRP, we prefer Alt.2. |
| Samsung | We do not support the proposal.  |
| Huawei/HiSilicon | For first path PRS RSPR, if it is up to UE select the first path, we should enable reporting the relative TOA for the first path.For the following case:First path of PRS resource #0First path of PRS resource #1/2/3It is likely the first path received by PRS resource#0 corresponds to the reflecting path 1 while the first path received by PRS resource#1/2/3 corresponds to the direct path 0. How network should use the first path measurement for PRS resource #0/1/2/3 reported by the UE without knowing if they are time aligned?Replied to QCFor additional path DL-AoD, we did some evaluation for additional path UL-AoA in the SI, which we think also applies to DL-AoD.We do not think combining DL-AoD with DL-TDOA can provide **angle estimation for additional paths**, yet for UL methods, we already agreed (path RSRP, AoA, TOA) tuples can be reported for the first path and additional paths. |
| ZTE | Agree with Nokia. We should change the main bullet to first detected path. And additional paths can be discussed in AI 8.5.1. We support to report timings of first detected path. This is to identify which DL PRS resource corresponds to earliest first path (or LOS link) when the DL PRS resource experiences blockage loss. In this case, the LOS link may not have the largest first path RSRP.We Support first subbullet and Alt2 in the following revised proposal.**Revised proposal:****When path PRS RSRP for first detected path is reported for DL AOD, an associated timing measurement of the corresponding path can also be reported.*** **In a measurement report per TRP, the time of arrival of a reference PRS resource should be reported.**
* **For the first path PRS RSRP, downselect between:**
	+ **Alt1: The path PRS RSRP for all reported resources in the TRP correspond to the same time of arrival**
	+ **Alt2: an RSTD between a reference PRS resource and other PRS resources in the TRP is reported for the first path measurements in the TRP .**
 |
| vivo | We do not support the proposal.And for the issue of how to ensure the path power from multiple resources is from to a path, it can be resolved by UE implementation that UE knows the arrival time if UE wants to calculate PRS PRSPP.  |
| Intel  | Support, Alt 2 |
| Ericsson | OK with ZTE rewording fort he first path timing.  |
| Fraunhofer | Support, Alt2 |

#### Proposal 1.4 (receiver diversity)

####  Summary of the proposal

In [1] it is propose to consider the aspect of receiver diversity. In the current 38.215 specification, the text for both UL SRS path RSRP and DL PRS path RSRP follows the legacy description and expect the UE to report from the branch with highest power. In [1] it is identified that this might lead to multiple path for the same PRS being reported from different branches. The following is proposed:

|  |  |
| --- | --- |
| [1] | ***Proposal 3: For path DL PRS RSRP measurement reporting, when receiver diversity is in use, the reported path DL PRS RSRP shall be corresponding to the same Rx branch associated with the reported DL PRS RSRP.*** |

We can use the proposal as is for discussion.

#### First round of discussion

A proposal for time of arrival reporting was discussed briefly during RAN1#106b-e, without reaching consensus. Several companies mention that time information should be an RSTD relative to the initial path. It is proposed to start the discussion based on the following proposal:

 **Proposal 1.4: For path DL PRS RSRP measurement reporting, when receiver diversity is in use, the reported path DL PRS RSRP shall be corresponding to the same Rx branch associated with the reported DL PRS RSRP.**

Companies are encouraged to provide comments in the table below.

**Proposal 1.4**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Fraunhofer | To make sure we have the correct understanding, the “Rx branch” here means the reception spatial domain filter so we are not introducing a new term.  |
| Huawei, HiSilicon | To Fraunhofer:No, to our understanding, this is not about Rx beam, but about Rx chain. Each Rx chain could form multiple Rx beams for FR2. |
| Nokia/NSB | We are expecting that the UE always report the RSRP corresponding to the same Rx branch to avoid the confusion from LMF, but if the specfication is really necessary we are okay. |

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

#### Summary and Proposal 2.1

During RAN1#106b-e, candidate values for the number of DL PRS RSRP and RSRPP measurement per TRP were agreed:

|  |
| --- |
| Agreement:The agreement from RAN1#106e on the number of DL PRS RSRP measurements per TRP is extended as follows:* For UE-A DL-AOD, support reporting ~~more than 8~~ up to ~~16~~ N DL PRS RSRP measurements per TRP, where N is UE capability and candidate values include {16,24}.
* For UE-A DL-AOD, support reporting ~~more than 8~~ up to ~~16~~ M first path PRS RSRP measurements per TRP, where M is a UE capability
	+ FFS: Values of M. Candidate values include {2,4,8,16,24}.
	+ FFS: Whether M is always equal to N
* Note: Multiple RSRPs corresponding to same or different Rx Beam index should be able to be reported for a given PRS resource for same or different timestamps.
* Note: the maximum number of DL PRS RSRP associated with the same Rx beam index is up to the UE implementation
 |

The following remaining issues are treated in the proposals:

* Extension of the indication of a common Rx beam index to between resources in different resource sets (currently restricted to within a resource set) [2]
* LMF requests to report the rx beam index [3]
* Number of reported PRS RSRP (N) and PRS RSRPP (M)
	+ M always equals N [4][15]
	+ M always is less or equal to N[6][8]
	+ N and M are independent [16]
	+ Max values for M :16 [8], {2,4,8,16,24}[18]
	+ Max values for N: 16 [8], {2,4,8,16,24}[18]

|  |  |
| --- | --- |
| 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 indicates 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.*  |
| [3] | ***Proposal 2:**** ***To improve the accuracy of DL-AoD and to avoid the impact of Rx beam, support the following options:***
	+ ***The LMF requests a UE to report the Rx beam index for multiple DL PRS RSRP measurements from a TRP.***
	+ ***The UE may report RxBeamIndex for a DL PRS RSRP measurement***
* ***The maximum number of DL PRS RSRP to be reported per TRP is 16.***
* ***The maximum number of path PRS RSRP to be reported per TRP is 16.***
 |
| [4] | ***Proposal 2: The number of first path PRS RSRP measurements reported per TRP is always equal to that of DL PRS RSRP measurements per TRP.*** |
| [6] | **Proposal 3**: the maximum number of PRS RSRPP measurement reporting for the first path should be less than or equal to the maximum number of PRS RSRP measurement reporting. That is, $M\leq N$ of the previous agreement.  |
| [8] | **Proposal 8*** **The total number of DL PRS RSRP measurements per TRP for the UE-assisted DL-AOD positioning method should be extended as follows:**
	+ **Support reporting up to *N* DL PRS RSRP measurements per TRP, where *N* = 16**
	+ **Support reporting up to *M* first path PRS RSRP measurements per TRP, where 2 ≤ *M* ≤ *N* = 16**
 |
| [15] | ***Proposal 1:**** Support that the value of M is equal to the value of N representing the number of RSRP measurements.

***Proposal 7:**** 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 8:**** 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.
 |
| [16] | **Proposal 4-1**: Support UE to report first path RSRP measurement only and therefore, N could be 0 and M > N, where N is for RSRP measurement and M is for first path RSRP measurement |
| [18] | ***Proposal 8: For UE-A DL-AOD, on the maximum number ‘M’ of first path RSRP measurements per TRP, support the following candidate values: {2,4,8,16,24}.******Proposal 9: For UE-A DL-AOD, support the option a UE to report separate maximum values for M (maximum number of first path RSRP measurements) and N (maximum number of PRS RSRP measurements per TRP).*** |

#### First round of discussion

Based on the proposals at least the value M=16 and N=16 seem to be agreeable. Additional values are proposed by at least 1 company. Request and reporting of common rx beam across PRS resource sets have not been discussed before but we can try and see if consensus can be reached.

**Proposal 2.1**

 **For reporting of DL PRS RSRPP and PRS RSRP in UE-A DL-AOD**

* **The maximum number of DL PRS RSRPP M is a UE capability and its candidate values include {2,4,8,16,24}.**
* **The capabilities for DL PRS RSRPP (M value) and DL PRS RSRP (N values) are such that M is less or equal to N**

Companies are encouraged to provide comments in the table below.

**Proposal 2.1**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Ok with the first 2 subbulets. The remaining 2 bullets are not needed. In either case, these are low priority details, and if needed could go directly to UE capability session. |
| Nokia/NSB | We are okay with the first two sub-bullets. In our understanding, the first two bullets are continuous discussion about the extending the maximum number of the RSRP reporting more than 8. We prefer to first conclude the discussion on the maximum number of RSRP rerpotings. And suggest a separate discussion on the third and fourth sub-bulles. We would expect that the UE basically report the RSRP and RSRPP for a PRS resource with the same Rx beam to avoid confusion from LMF. |
| OPPO | We are only ok with the first two bullets too. The 3rd and 4th bullets are not needed. |
| CATT | We prefer the following updated proposal:**Updated Proposal 2.1**  **For reporting of DL PRS RSRPP and PRS RSRP in UE-A DL-AOD*** **The maximum number of DL PRS RSRPP M is a UE capability and its candidate values include {~~2,4,8,~~16,24}.**
* **The capabilities for DL PRS RSRPP (M value) and DL PRS RSRP (N values) are such that M is ~~less or~~ equal to N**
* **The UE may indicate which DL PRS RSRP or DL PRS RSRPP measurement from PRS resources in the same PFL associated with the same rx beam index if there are at least 2 DL PRS RSRP or 2 DL PRS RSRPP associated with this Rx beam in the PFL.**
* **The LMF may request the UE to perform multiple RSRP or RSRPP measurements with the same rx beam**
 |
| Samsung | We are okay to discuss the first 2 bullets |
| Huawei, HiSilicon | We also do not think the last two bullets are needed now. |
| ZTE | We prefer the first two subbullets from updated proposal by CATT. |
| MTK | 1, support first bullet2, for 2nd bullet, the number between M and N. It seems to us that M=N, or N=0 and just report M could be considered. M=N are used for LOS/NLOS and we already support the reporting of LOS/NLOS indicator with soft value. So we doubt whether the further reporting of PRS RSRP is needed. RSRP**P** is sufficient |
| Intel  | Support first two bullets, same view as QC.  |
| Lenovo, Motorola Mobility | The last two bullets can be further decided. Similar to most companies, supportive of the first 2 bullets. |
| FL | Let’s discussed the last two bullets in a separate proposal (see proposal 2.2). Seems more discussion is needed fort he relation between M and N.  |

#### Proposal 2.2

####  First round of discussion

**Proposal 2.2:**

* **The UE may indicate which DL PRS RSRP or DL PRS RSRPP measurement from PRS resources in the same PFL associated with the same rx beam index if there are at least 2 DL PRS RSRP or 2 DL PRS RSRPP associated with this Rx beam in the PFL.**
* **The LMF may request the UE to perform multiple RSRP or RSRPP measurements with the same rx beam**

Companies are encouraged to provide comments in the table below.

**Proposal 2.2**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia/NSB | We are not supportive of this proposal as do not see the necessity. |

###  Aspect #3 adjacent beam reporting

#### Summary

This aspect did not converge during RAN1#106b-e, but the proposal went through several rounds. The latest proposal was:

|  |
| --- |
| **Proposal 3.1c****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 may indicate in the assistance data (AD), one or both the following:** * **option 1: subject to UE capability, for each PRS resource, a subset of PRS resources ~~which indicates the beam information~~ for the purpose of prioritization of DL-AOD ~~measurement and~~ reporting:**
	+ **a UE may include the requested PRS measurement for the subset of the PRS in the DL-AoD additional measurements if the requested PRS measurement of the associated PRS is reported**
		- **The requested PRS measurement can be DL PRS RSRP and/or path PRS RSRP.**
	+ **Note: The subset associated with a PRS resource can be in a same or different PRS resource set than the PRS resource**
* **option 2: subject to UE capability, for each PRS resource, the boresight direction information, and optionally an the expectedDLAoD for each TRP.**
* **Note: Either case does not imply any restriction on UE measurement**
* **FFS: prioritization of the PRS resources and resource subsets to be measured**
* **FFS: UE may report PRS measurements only for the subset of PRS resources.**
 |

 Similar to RAN1#106b-e, the proposals for this meeting are split between either associating a subset of PRS resources for adjeacent beam reporting, or indication of boresight direction information:

* PRS subset indication and reporting is proposed by [1][3][4][5][6][9][10][11][12][15][16][18][19][20]
	+ [6] also propose to use this feature to support two-stage beam sweeping
	+ [20] also proposes to report the adjeacent beams with the same rx beam.
* Boresight direction information / expected DL AOD for each TRP is proposed by [4][6][7][16][18][19]

|  |  |
| --- | --- |
| Source | Proposal |
| [1] | ***Proposal 5: 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 which indicates the beam information for the purpose of prioritization of DL-AOD measurement and reporting:**** ***The subset associated with a PRS resource can be in a different PRS resource set than the PRS resource.***
* ***Subject to UE capability, a UE may include the RSRPs for the subset of the PRS in the DL-AoD additional measurements if RSRP of the associated PRS is reported in nr-DL-PRS-RSRP-Result.***
* ***Note: This does not imply any restriction on UE measurement.***
 |
| [3] | ***Proposal 8**** ***For UE-A DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s) reporting, the LMF indicates in the assistance data (AD) for each PRS resource, a subset of PRS resources:***
	+ ***Subject to UE capability, support the LMF to request a UE to optionally report the RSRPs for the subset of the PRS in the DL-AoD additional measurements if RSRP of the associated PRS is reported in nr-DL-PRS-RSRP-Result.***
 |
| [4] | ***Proposal 3: For UE-Based and UE-Assisted DL-AOD positioning method in Rel-17, both option 1 and option 3 of the agreement of the RAN1#105-e 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***
 |
| [5] | Proposal 3: For UE-assisted DL-AoD positioning, 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.
 |
| [6] | **Modifed Proposal 3.1c of [7]**For UE-assisted DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s) reporting, the LMF may indicate in the assistance data (AD), one or both the following: * option 1: subject to UE capability, for each PRS resource, a subset of PRS resources for the purpose of prioritization of DL-AOD reporting:
	+ a UE may include the requested PRS measurement for the subset of the PRS in the DL-AoD additional measurements if the requested PRS measurement of the associated PRS is reported
		- The requested PRS measurement can be DL PRS RSRP and/or path PRS RSRP.
	+ *A UE may report PRS measurements only for the subset of PRS resources.*
	+ Note: The subset associated with a PRS resource can be in a same or different PRS resource set than the PRS resource
* option 2: subject to UE capability, for each PRS resource, the boresight direction information, and optionally an the expectedDLAoD for each TRP.
* Note: Either case does not imply any restriction on UE measurement
* FFS: prioritization of the PRS resources and resource subsets to be measured

**Proposal 8:** Support the modified proposal 3.1c. |
| [7] | **Proposal 3: support LMF to indicate UE of the resource IDs, which corresponds to the boresight direction and the expected AoD range, in the assistance data report.** **Proposal 4: Defining adjacent beam is UE implementation. No indication from LMF is needed.**  |
| [9] | *Proposal 1: Adjacent PRS resources can be predefined by resource index.**Proposal 2: For UE-assisted DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s) measurement and reporting, in order to reduce the number of measured PRS resource, the LMF indicates in the assistance data (AD) for each PRS resource, a subset of PRS resources which indicates the beam information for the purpose of DL-AOD measurement.* |
| [10] | **Proposal 1: For UE-assisted DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s)** **reporting, the LMF may indicate in the assistance data (AD):*** **Option 1: Subject to UE capability, for each PRS resource, a subset of PRS resources for the purpose of prioritization of DL-AOD** **reporting:**
	+ **a UE may include the requested PRS measurement for the subset of the PRS in the DL-AoD additional measurements if the requested PRS measurement of the associated PRS is reported**
		- **The requested PRS measurement can be DL PRS RSRP and/or path PRS RSRP.**
	+ **Note: The subset associated with a PRS resource can be in a same or different PRS resource set than the PRS resource**
 |
| [11] | ***Proposal 1: For adjacent beam reporting, Option 1 is more preferred: subject to UE capability, for each PRS resource, a subset of PRS resources for the purpose of prioritization of DL-AOD reporting.*** |
| [12] | ***Proposal 2: 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.*** |
| [15] | ***Proposal 6:**** 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’)
 |
| [16] | **Proposal 2-1**: Agree the two options for adjacent beam reporting |
| [18] | ***Proposal 7: For UE-assisted DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s) reporting, the LMF may indicate in the assistance data (AD), one or both the following:*** * ***option 1: subject to UE capability, for each PRS resource, a subset of PRS resources for the purpose of prioritization of DL-AOD reporting:***
	+ ***a UE may include the requested PRS measurement for the subset of the PRS in the DL-AoD additional measurements if the requested PRS measurement of the associated PRS is reported***
		- ***The requested PRS measurement can be DL PRS RSRP and/or path PRS RSRP.***
	+ ***Note: The subset associated with a PRS resource can be in a same or different PRS resource set than the PRS resource***
* ***option 2: subject to UE capability, for each PRS resource, the boresight direction information, and optionally an the expectedDLAoD for each TRP.***
* ***Note: Either case does not imply any restriction on UE measurement***
 |
| [19] | ***Proposal 3: Support transmitting the beam information with an explicit order of priority of beams carrying the subset of PRS resources. Explicit priority indications for measurement and reporting can be configured by the LMF.******Proposal 4: Extend the current DL-AoD framework of providing boresight information in the case of UE-assisted DL-AoD positioning.*** |
| [20] | Proposal 9: 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 may indicate in the assistance data (AD) according to Option 1 in the FL summary.**Proposal 10: The UE should prioritize reporting first path PRS RSRPP or RSRP for the indicated subset of associated PRS Resources over other PRS resources.*****Proposal 15 First path PRS-RSRP measurements of adjacent DL PRS Resources that the UE reports should be performed using the same Rx-beam.*** |
| [21] | **Proposal 1: For UE-assisted DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s) reporting, the LMF may indicate in the assistance data (AD), one or both the following:** * **Option 1: subject to UE capability, for each PRS resource, a subset of PRS resources for the purpose of prioritization of DL-AOD reporting:**
	+ **a UE may include the requested PRS measurement for the subset of the PRS in the DL-AoD additional measurements if the requested PRS measurement of the associated PRS is reported**
		- **The requested PRS measurement can be DL PRS RSRP and/or path PRS RSRP.**
	+ **Note: The subset associated with a PRS resource can be in a same or different PRS resource set than the PRS resource**
* **Option 2: subject to UE capability, for each PRS resource, the boresight direction information, and the expected DL-AoD for each TRP.**
* **Note: Either case does not imply any restriction on UE measurement**
 |

#### Proposal 3.1 (adjacent beams signalling and reporting)

####  First round of discussion

Since the discussion in the proposal is a direct continuation from the last meeting, Proposal 3.1e from RAN1#106e can be re-used as a starting point, with the proposal from [6] on reporting only for the PRS subset added as a bullet. If an agreement is reached, we can discuss the prioritization of resources in a second step.

**Proposal 3.1:**

**For UE-assisted DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s) reporting, the LMF may indicate in the assistance data (AD), one or both the following:**

* **option 1: subject to UE capability, for each PRS resource, a subset of PRS resources ~~which indicates the beam information~~ for the purpose of prioritization of DL-AOD ~~measurement and~~ reporting:**
	+ **a UE may include the requested PRS measurement for the subset of the PRS in the DL-AoD additional measurements if the requested PRS measurement of the associated PRS is reported**
		- **The requested PRS measurement can be DL PRS RSRP and/or path PRS RSRP.**
	+ **UE may report PRS measurements only for the subset of PRS resources.**
	+ **Note: The subset associated with a PRS resource can be in a same or different PRS resource set than the PRS resource**
* **option 2: subject to UE capability, for each PRS resource, the boresight direction information, and optionally an the expectedDLAoD for each TRP.**
* **Note: Either case does not imply any restriction on UE measurement**
* **FFS: prioritization of the PRS resources and resource subsets to be measured**

Companies are encouraged to provide comments in the table below.

**Proposal 3.1:**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | With regards to this bullet:* “ UE may report PRS measurements only for the subset of PRS resources„

Obviously this can happen, not sure what value this has. We also dont think the „FFS“ is needed. We need to close the issues, and keeping this open, is not really essential.  |
| Nokia/NSB | Support. If the bullet “ UE may report PRS measurements only for the subset of PRS resources“ is not included, it looks like the sub-set of PRS resources should be reported as additional measurement. We prefer to keep the proposal as it is. |
| OPPO | Do not support to include the “ an the expectedDLAoD for each TRP“ in Option 2. That has been dicussed quite a few times. Providing a expected DL AoD to a UE does not work technically. **Proposal 3.1:** **For UE-assisted DL-AOD positioning method, to enhance the signaling to the UE for the purpose of PRS resource(s) reporting, the LMF may indicate in the assistance data (AD), one or both the following:** * **option 1: subject to UE capability, for each PRS resource, a subset of PRS resources ~~which indicates the beam information~~ for the purpose of prioritization of DL-AOD ~~measurement and~~ reporting:**
	+ **a UE may include the requested PRS measurement for the subset of the PRS in the DL-AoD additional measurements if the requested PRS measurement of the associated PRS is reported**
		- **The requested PRS measurement can be DL PRS RSRP and/or path PRS RSRP.**
	+ **UE may report PRS measurements only for the subset of PRS resources.**
	+ **Note: The subset associated with a PRS resource can be in a same or different PRS resource set than the PRS resource**
* **option 2: subject to UE capability, for each PRS resource, the boresight direction information~~, and optionally an the expectedDLAoD for each TRP.~~**
* **Note: Either case does not imply any restriction on UE measurement**
* **FFS: prioritization of the PRS resources and resource subsets to be measured**
 |
| InterDigital | Support |
| CATT | Support.We prefer to adopt both options. |
| Samsung | Support the proposal |
| Huawei, HiSilicon | We do not support Option 2, which has been discussed for quite a few meetings. OK with Option 1 only. |
| vivo | Support at least for option1 since we have discussed multiple meetings. |
| Lenovo, Motorola Mobility | Support FL’s proposal with both options |
| Fraunhofer | We are okay with the two options as a way forward. |
| Nokia/NSB | If issue on the expected DL-AoD is critical barrier for making progress on this proposal, we suggest making conclusion of Aspect#5 first . |

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

#### Summary

The discussion did not converge during RAN1#106b-e, and it seems the same positions are help by the companies in this round of proposal:

* Option 2.1 is proposed in [3][4][5][6] [7] (beamwidth and gain only),[8][11][13][18][20] (with support of beamwidth and gain possible), [21]
* Option 2.2 is supported by in [1][2][3][9][16]
* Reporting of Tx beam codebook [7]

|  |  |
| --- | --- |
| Source | Proposal |
| [1] | ***Proposal 4: For DL-AoD angle calculation enhancements, the gNB reports the quantized version of the relative power between PRS resources per angle per TRP.******The quantized relative power follow the mapping of differential RSRP*** |
| [2] | ***Proposal 4:*** *For the beam/antenna information to be optionally provided to the LMF by the gNB, support Option 2.2,** *The gNB reports quantized version of the relative power between PRS resources per angle per TRP.*
* *The relative power is defined with respect to the peak power in each angle*
* *For each angle, at least two PRS resources are reported.*

***Proposal 5****: Range of angles [θ1,θ2] are determined by,** *For beam information provided by gNB/TRP to LMF, the range of angles [θ1,θ2] can either decided by gNB/TRP or requested by LMF*
* *For beam information provided by LMF to UE (at least for UE based positioning), the range of angles [θ1,θ2] can be implicitly indicated by AoD uncertainty window as default for [θ1,θ2] if the range is not configured and the uncertainty window is available.*
 |
| [3] | ***Proposal 3:**** ***Choose one option for the beam/antenna information***
	+ ***Option 2.1: The gNB reports quantized version of the relative Power/Angle response per PRS resource per TRP***
		- * + ***Reporting the peak power of that resources together***
	+ ***Option 2.2: The gNB reports quantized version of the relative Power between PRS resources per angle per TRP.***

***Proposal 4**** ***Support*** ***the following angle range and angle granularity for relative Power/Angle response***
	+ ***[-90, 90] for omnidirectional antenna and [-60, 60] for directional antenna***
		- * + ***0 degree is represented as the boresight angle of the resource.***
	+ ***Granularity angle can be 0.5, 1, 2, 4 degrees.***

***Proposal 5**** ***Support*** ***the quantization accuracy of relative power refer to the reporting range of differential PRS-RSRP is defined from -30 dB to 0 dB with 1 dB resolution as in TS 38.133***

**Proposal 6:*** ***Support reusing of associated-dl-PRS-Id for 2 TRPs have the same beam information***
* ***To consider associated-PRS-resource-ID for 2 resources have the same beam information and different boresight angle.***

***Proposal 7:**** ***Support reporting 4 parameters (horizontal number of antennas, vertical number of antennas, dH, dV) for one resource as an overhead reduced mechanism and without quantized method for DFT beam.***
 |
| [4] | ***Proposal 6: For the beam/antenna information provided to the LMF, the gNB could report quantized version of the relative Power/Angle response per PRS resource per TRP.*** |
| [5] | Proposal 5: Support to select Option 2.1 for providing beam/antenna information to the LMF by the gNB.***Proposal 6: The gNB reports the peak beamforming gain of each PRS resource to the LMF:**** ***The gNB can indicate which PRS resource has the largest peak beamforming gain.***
* ***The gNB reports the relative peak beamforming gain of other PRS resource with respect to the PRS resource with the largest peak beamforming gain.***

Proposal 7: The TRP reports the relative beamforming gain per angle for each PRS resource in IE NR PRS beam information.Proposal 8: The TRP reports the information of peak beamforming gain for each PRS resource.Proposal 9: Multi-level quantization is supported for relative beamforming gain reporting:* For example, 1dB step size is used for relative power gain from 0 to -10dB and 3dB step size is used for relative power gain < -10dB.
 |
| [6] | **Proposal 4:** Support option 2.1: The gNB reports quantized version of the relative Power/Angle response per PRS resource per TRP. |
| [7] | **Proposal 5: In case of using multiple sweeping beams with MIMO, support gNB to report the Tx beam codebook to the LMF to assist the positioning estimation.** **Proposal 6: Optionally, support Tx beam configuration, such as beamwidth and gain, sent from gNB to LMF, for minimizing the reporting size.** |
| [8] | **Proposal 3*** + **Support option 2.1 where gNB reports quantized version of the relative power corresponding to the set of the sampled azimuth and zenith angles per PRS Resource per TRP**
		- **The relative power is defined with respect to the peak power of that resource**

**Proposal 4*** + **Support uniform sampling for the azimuth angle *φ* in the spatial sector [-(*N*/2)×Δ*φ*, +(*N*/2)×Δ*φ*], defined by the parameters Δ*φ* and *N*, where**
		- **Δ*φ* is the spatial resolution, defined in deg**
		- ***N* +1 is the total number of samples per spatial sector**
	+ **For a given azimuth angle, support uniform sampling for the zenith angle *θ* in the spatial sector [-(*M*/2)×Δ*θ*, +(*M*/2)×Δ*θ*], defined by the parameters Δ*θ* and *M*, where**
		- **Δ*θ* is the spatial resolution, defined in deg**
		- ***M* is the total number of samples per spatial sector**

**Proposal 5*** + **Support quantization of the power levels in the decibel scale in accordance with the following equation:**
		- ***PL*(*n*) = 20×lg(*n*) - 20×lg(2*Nb*), where *PL*(*n*) corresponds to the power of the *n*th level with the total number of levels equal to 2*Nb***
		- ***Nb* is the number of bits used to signal a power level value**
		- ***PL* = 0 dB corresponds to the peak power of the PRS Resource**
		- ***PL* = - 20×lg(2*Nb*) dB corresponds to the sensitivity level or the minimum value used to signal a power level value**
	+ ***Nb* parameter can be set as one of the following {2, 3, 4, 5, 6, 7, 8} bits**
		- **The choice of the *Nb* parameter provides a trade-off between the required accuracy and signaling overhead**
 |
| [9] | *Proposal 4: Slightly prefer Option 2.2 for UE-B DL AoD positioning for the beam/antenna information provided by gNB.* |
| [11] |  ***Proposal 2: For Support of additional gNB beam information,Option 2.1 is more preferred: The gNB reports quantized version of the relative Power/Angle response per PRS resource per TRP.*** |
| [13] | **Proposal 3: Support Option 2.1, “The gNB reports quantized version of the relative Power/Angle response per PRS resource per TRP”****Proposal 4: Under Option 2.1, “The gNB reports quantized version of the relative Power/Angle response per PRS resource per TRP”, support to include information related to -3dB power level** |
| [16] | **Proposal 3-1**: For gNB beam information, at least the option 2.2 is supported**Proposal 3-2**: For the gNB without the concern to disclose beam design, option 2.1 is also supported**Proposal 3-3**: Have a note for the agreement that, both options don't influence the UE reporting**Proposal 3-4**: Have a note for the agreement that, both options don't influence LMF to look up the angle |
| [18] | ***Proposal 1: For beam-shape signaling, include additional signaling to allow a full comparison of beam strengths across angles and PRS resources.*** * ***For Option 2.1: also report the peak strength across angles for each resource, relative to the peak of this quantity across all resources***
	+ A normalized version of the vector $\left[\max\_{A}\left(P(A,1)\right),\max\_{A}\left(P\left(A,2\right)\right),…,\max\_{A}\left(P\left(A,N\right)\right)\right], $where N is the number of PRS resources of the TRP
* ***For Option 2.2: also report the peak strength across resources for each angle, relative to the peak of this quantity across all angles.***
	+ A normalized version of the vector $\left[\max\_{j}\left(P(A\_{1},j)\right),\max\_{j}\left(P\left(A\_{2},j\right)\right),…,\max\_{j}\left(P\left(A\_{K},j\right)\right)\right], $where K is the number of angles in the set A.

***Proposal 2: Support Option 2.1 of proposal 1 rather than Option 2.2.******Proposal 3: Introduce more than one levels of quantization for the beam information to trade-off beam representation accuracy and overhead. For Option 2.1 support at least the following cases:**** ***Case 1: Configuration of one or more uniform grids in azimuth and zenith using the following parametrization per grid:***
	+ ***Azimuth: (***$ϕ\_{start}, Δϕ, ϕ\_{End}$***),***
	+ ***Zenith: (***$θ\_{start}, Δθ, θ\_{End}$***)***

 ***where*** $Δϕ$ ***and*** $Δθ$ ***can at least take the values {0.5, 1, 2, 5} degrees.*** * ***Case 2: Explicit configuration of (***$ϕ\_{i},θ\_{i})$ ***for each reported power value for each PRS resource***

***Proposal 4: 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.*** |
| [20] | **Proposal 11 The LMF should be provided information of beams associated with PRS Resources over O&M. This can be done without specification impact.****Proposal 12 Option 2.1 is reformulated as: The beam/antenna information consists of beam peak direction and a quantized version of the relative Power/Angle response per PRS resource per TRP. The relative power is defined with respect to the peak power of that resource.****Proposal 13 For Option 2.1, if the peak power of different DL PRS Resources at their respective peak directions are different, then their relative differences can be provided to LMF.****Proposal 14 For Option 2.1, include the angles at only the -3dB relative power level.** |
| [21] | **Proposal 2: Support that the gNB reports quantized version of the relative Power/Angle response per PRS resource per TRP (Option 2.1).** |

#### Proposal 4.1 (signalling of beam information)

####  First round of discussion

Before going into the details of granularity of beam information, one of the option should be selected. To start the discussion, option 2.1 is proposed as it is the majority option. The FFS should be resolved during this meeting as well if RAN1 wants to complete the issue in time.

It should also be noted that an LS to RAN1 from RAN3 on the issue is also currently being discussed in RAN3#114e[22]

**Proposal 4.1**

**For the beam/antenna information to be optionally provided to the LMF by the gnodeB, the following option is supported in the agreement from RAN1#106e**

* **Option 2.1: The gNB reports quantized version of the relative Power/Angle response per PRS resource per TRP**
	+ **The relative power is defined with respect to the peak power of that resource**
	+ **FFS: How many relative power levels can be included (e.g., single -3 dB power-levels, multiple power-levels, etc).**

Companies are encouraged to provide comments in the table below.

**Proposal 4.1**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Support. Highest priority in this agenda to finish with this. This topic needs to be discussed first.  |
| Nokia/NSB | Support |
| OPPO | Support |
| CATT | Support. |
| Huawei, HiSilicon | We do not support the proposal. In the contribution, we already made extensive comparison between two options.

|  |  |
| --- | --- |
| **Option 2.1** | **Option 2.2** |
| Peak power difference between PRS resources required. | The peak power on each angle is the reference power, and there is no requirement to know the peak power difference between PRS resources |
| gNB antenna radiation pattern revealed | gNB antenna radiation pattern concealed. |
| Not easy to collect data in the real field | Use of PRU can easily collect data. |
| The angle entries for each PRS resource should be regularly sampled. | The angle entries can be flexibly/non-uniformly sampled in space. |
| LMF needs to convert the beam pattern to Option 2.2 representation to match the UE RSRP reporting. | Option 2.2 is directly matched with UE RSRP reporting. |
| Large overhead for beam pattern | 25% overhead reduction compared with Option 2.1. |
| More overhead if multi-peak beam deployed. | No overhead increase for multi-peak beam pattern. |

 |
| ZTE | Our first preference is to support Option 2.2. If we cannot get consensus, we’re fine to not support this feature as it can be provided by OAM.  |
| MTK | Dont support. For both options, it doesn‘t impact LMF’s looking up the direction, and option 2.2 is good for gNB having concern on disclosing the beam design. |
| Intel  | Support  |

|  |  |
| --- | --- |
| Ericsson | We have a similar view as ZTE that the solution can still be provided by OAM. Additionally, the discussion based on our LS to RAN3 was held in RAN3, but the group could not reach consensus. Since the impact from this proposal is mostly on RAN3, we should make sure that any agreement is aligned with RAN3. Suggest to reword the agreement as: **From the RAN1 perspective, For the beam/antenna information to be optionally provided to the LMF by the gnodeB, the following option is preferred:*** **Option 2.1: The gNB reports quantized version of the relative Power/Angle response per PRS resource per TRP**
	+ **The relative power is defined with respect to the peak power of that resource**
	+ **FFS: How many relative power levels can be included (e.g., single -3 dB power-levels, multiple power-levels, etc).**
* **Send an LS to RAN3 to see if signalling can be realized in RAN3.**
 |
| Fraunhofer | Support |

###  Aspect #5 AoD uncertainty window

#### Summary and FL proposal 5.1

Proposals are similar to the ones in RAN1#106b-e, where the following was discussed:

|  |
| --- |
| **Proposal5.1b:**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.
* FFS: details of signaling
* FFS: Applicability to other Positioning methods
 |

* AoD/ZoD expected value and uncertainty (option 1 in previous meetings) is supported by [2][6][8][9][12] [14] [15] [18] (ue based and on demand prs)
	+ In [20] the window is realized with a list of PRS indices.
* AoA/ZoA expected value and uncertainty (option 2 in previous meetings) is supported by [6] [15]
* No further specification:[5]
* Signalling of boresight direction for each PRS in AD [13]
* Indication of a reference resource for AoD/ZoD or AoA/ZoA is proposed in [4]

|  |  |
| --- | --- |
| Source | Proposal |
| [2] | ***Proposal 3:*** *For the purpose of both UE-B and UE-A DL-AoD, support an expected uncertainty window as assistance data,** *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.*
 |
| [4] | ***Proposal 4: 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.*** |
| [5] | Proposal 4: On uncertainty window for DL-AoD, support Option 3, i.e., do not introduce expected AoD/ZoD or AoA/ZoA and uncertainty |
| [6] | **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. |
| [8] | **Proposal 6*** **For the UE-based and UE-assisted DL-AOD positioning methods, support option A, where the expected value and uncertainty range signaling by the LMF to the UE for each TRP in the format:**
	+ **Expected azimuth angle of departure is defined 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 is defined as (θAOD - ΔθAOD/2, θAOD + ΔθAOD/2)**
		- **θAOD - expected zenith angle of departure, ΔθAOD – uncertainty range for expected zenith angle of departure**
	+ **GCS is supported for the AOD/ZOD assistance information signaling**

**Proposal 7*** **The gNB may report the expected value and uncertainty range for each of the TRPs to the LMF using the NRPPa protocol as a part of the TRP information exchange in the format:**
	+ **Expected azimuth angle of departure is defined 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 is defined as (θAOD - ΔθAOD/2, θAOD + ΔθAOD/2)**
		- **θAOD - expected zenith angle of departure, ΔθAOD – uncertainty range for expected zenith angle of departure**
	+ **GCS is supported for the AOD/ZOD assistance information signaling**
 |
| [9] | *Proposal 3: 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.*
 |
| [12] | ***Proposal 3: For the purpose of both UE based and UE assisted DL-AoD, the LMF can provide the UE with the expected DL-AoD/ZoD value and uncertainty (of the expected DL-AoD/ZoD value) ranges if these can be accurately determined.*** |
| [13] | **Proposal 5: For UE-assisted DL-AOD positioning method, the LMF can include boresight direction information for each PRS resource in the assistance data.** |
| [14] | **Proposal 2**: For DL-AoD technique, support DL-AoD/ZoD assistance information (expected and uncertainty window), signaled from LMF to the UE for each TRP measurement. |
| [15] | ***Proposal 5:*** * Regarding expected uncertainty window for DL-AoD enhancement, RAN1 should support both options (Expected DL-AoD/ZoD and expected DL-AoA/ZoA).
 |
| [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 6: 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***
* ***For UE-A, if expected Angle of Departure is signaled, beam-shape details shall also be signaled.***
 |

#### First round of discussion

Since the majority of proposal are in support of option 1 (AoD/ZoD expected value and uncertainty), in the same way as during RAN1#106b-e, we can continue the discussion with the proposal from RAN1#106b-e.

**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.**
* **FFS: details of signaling**
* **FFS: Applicability to other Positioning methods**

Companies are encouraged to provide comments in the table below.

**Proposal 5.1**

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Qualcomm | Support.  |
| Nokia/NSB | Support FL proposal. We are also okay with both options including the expected DL-AoA |
| OPPO | Do not support. Technically, providing such information does not provide any valid information. For instance, the coordinate of TRP is not known by the UE in UE-A positioning method, then how can the expected AoD/ZoD value work? |
| InterDigital | Support |
| CATT | Support. |
| Samsung | Support |
| Huawei, HiSilicon | We do not need FFS for this meeting unless we want to resolve this by this meeting.We would be OK with the following modification.**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 angle value and uncertainty (of the expected azimuth and zenith angle value) range(s) is signaled by the LMF to the UE**
* **The angle value can be described either from TRP perspective or from UE perspective.**
 |
| ZTE | Support. To OPPO, we don’t need to provide TRP location if boresight directions of DL PRS resources are provided to UE. For progress, we’re fine to agree UE based positioning first. We can FFS for UE assisted positioning. |
| Intel  | Support. In addition, we believe that it is also useful if gNB can report such information per TRP (expected DL-AOD value and uncertainty range) to the LMF.  |

###  Aspect #6 two-stage beam sweeping

#### Summary and FL proposal

The issue of beam refinement/two-stage beam sweeping was discussed in [2][4][5][6][12][13][15] with the following proposals:

* [5] proposes to support PRS beam information in UE assisted methods
* [4] proposes to support dynamic association between PRS resources in different resource sets of the same TRP. [13] proposes to support at least semi static association
* [6][12][15] discuss association/refinement between PRS in two separate resource sets in the same TRP
* [2] proposes to deprioritize the issue

|  |  |
| --- | --- |
| Source | Proposal |
| [2] | ***Proposal 7:*** *Don’t support or at least* *deprioritize corresponding enhancements on two-stage PRS beam sweeping.*  |
| [4] | ***Proposal 5: 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.*** |
| [5] | Proposal 10: For beam refinement on DL PRS:* Support to provide DL PRS beam information (NR-DL-PRS-BeamInfo) to the UE for UE-assisted methods.
* Do not introduce additional association between PRS resources for beam operation.
 |
| [6] | **Proposal 5:** LMF provides in the assistance data association information between two PRS resources where the two PRS resources are in different PRS resource set.According to current Rel-16 DL-AoD positioning measurement and report behavior, a UE shall measure all configured PRSs (probably with up to 2 resource sets) and report the highest RSRP (or multiple highest RSRP) and associated PRS ID(s). In two-stage beam sweeping, the first stage PRSs are used to identify preferred second stage PRSs to be measured. Reporting a PRS resource ID and RSRP measurement from the first stage resource set (or wide-beam resource set) is undesired and unnecessary for the final positioning estimation.**Proposal 6:** For the overhead reduction of PRS reporting for UE-assisted DL-AoD positioning, a UE may be able to report the DL PRS RSRPs only for the associated PRS resources within a single set if the LMF provided association information to the UE.One potential further enhancement for two-stage PRS beam sweeping is to reduce transmission overhead for PRSs, especially the second stage PRSs. It worths to study on-demand PRS (muting) framework for two-stage PRS and in particular look at ways to reduce the network overhead to minimize unnecessary PRS transmissions.**Proposal 7:** Support and study on-demand PRS framework for two-stage PRS beam sweeping.  |
| [12] | ***Proposal 4: 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.***  |
| [13] | **Proposal 2: At least a semi static relation between PRS resources in different PRS resource sets should be supported** |
| [15] | ***Proposal 9:**** 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.

***Proposal 10:**** RAN1 needs to consider applying different resolution and range for measured quantity value in each stage respectively.
 |

#### First round of discussion

From the FL perspective, it is unclear it seems unlikely that the issue can be resolved before the release end. Given the workload. However, given that several companies have proposal on the issue, the following is proposed for the discussion:

**Proposal 6.1**

**To enable 2-stage beam sweeping/refinement, the LMF can configure a a semi static relation between PRS resources in different PRS resource sets in the assistance data**

* **UE may send a report with the DL PRS RSRPs only for the associated PRS resources if the LMF provided association information to the UE.**

 Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Nokia/NSB | Support |
| OPPO | Do not support. The intention of the proposal 6.1 can be supported by either QCL configruation or providing boresight information of each PRS resource as in the proposal 3.1. |
| InterDigital | Support |
| CATT | We prefer the following updated proposal:**Updated Proposal 6.1**  **To enable 2-stage beam sweeping/refinement, the LMF can configure a ~~a semi static~~ relation between PRS resources in different PRS resource sets in the assistance data*** **UE may send a report with the DL PRS RSRPs only for the associated PRS resources if the LMF provided association information to the UE.**
* **FFS: such relation is semi-statically or dynamically configured**
 |
| Samsung | Support the proposal and we are also okay with CATT’s revision. |
| Huawei, HiSilicon | We think this is already under consideration of 2.1.3, where the subset association is exactly the association described here. |
| ZTE | Don’t support. |
| Lenovo, Motorola Mobility | Support |

##  Other aspects

|  |  |
| --- | --- |
| Source | Proposal |
| [6] | **Proposal 12:** 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 it when computing the position estimate.
* Signaling aspects:
	+ LMF signals to TRPs that a BO beam re-tuning is needed. The BO correction may be explicitly signalled to the TRP by the LMF; alternatively, the LMF may send a Boolean indication that a BO recomputation and adjustement is needed.
	+ UE measurement reports to facilitate BO identification and potential correction.

**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. |
| [15] | ***Proposal 2:**** RAN1 should consider introducing either the expected RSRP (including uncertainty) or expected path RSRP (including uncertainty) for UE to decide the FAP more properly.

***Proposal 3:**** RAN1 should consider introducing path RSRP quality (threshold) to restrict reporting redundant measurements.
	+ UE reports only measurements satisfying the path RSRP quality (threshold).
 |

#### Comments

|  |  |
| --- | --- |
| **Company** | **Comment** |
|  |  |

1. Conclusion

 **TBD**

1. References
2. R1-2110852, Remaining issues of DL AoD enhancements, Huawei, HiSilicon
3. R1-2110958, Accuracy improvement for DL-AoD positioning solutions, ZTE
4. R1-2111015, Remaining issues on potential enhancements for DL-AoD method, vivo
5. R1-2111258, Remaining issues on enhancements for DL-AoD positioning method, CATT
6. R1-2111291, Enhancements for DL-AoD positioning, OPPO
7. R1-2111366, Views on enhancing DL AoD, Nokia, Nokia Shanghai Bell
8. R1-2111399, Remaining aspects of DL-AoD enhancements, Sony
9. R1-2111497, Remaining Details of DL-AoD Enhancements for NR Positioning, Intel Corporation
10. R1-2111574, Accuracy improvements for DL-AoD positioning solutions, Xiaomi
11. R1-2111610, Discussion on DL-AoD enhancements, CMCC
12. R1-2111654, Discussion on enhancements for DL-AoD positioning, CAICT
13. R1-2111740, Discussion on accuracy improvements for DL-AoD positioning solutions, Samsung
14. R1-2111799, Enhancements for DL-AoD positioning solutions, InterDigital, Inc.
15. R1-2111876, Positioning Accuracy enhancements for DL-AoD, Apple
16. R1-2111975, Discussion on accuracy improvement for DL-AoD positioning, LG Electronics
17. R1-2112072, Accuracy enhancement for DL-AOD technique, MediaTek Inc.
18. R1-2112110, Discussion on DL-AoD positioning enhancements, NTT DOCOMO, INC.
19. R1-2112219, Remaining Issues on Potential Enhancements for DL-AoD positioning, Qualcomm Incorporated
20. R1-2112324, Remaining issues on DL-AoD Positioning Enhancements, Lenovo, Motorola Mobility
21. R1-2112341, Enhancements of DL-AoD positioning solutions, Ericsson
22. R1-2112367, DL-AoD positioning enhancements, Fraunhofer IIS, Fraunhofer HHI
23. <https://www.3gpp.org/ftp/tsg_ran/WG3_Iu/TSGR3_114-e/Inbox/Drafts/CB%20%23%204_PositioningDLAOD>