**3GPP TSG-RAN WG2 Meeting #116bis R2-21xxxxx**

**Online, 17 – 26 January 2022**

**Agenda item:** 8.11.17

**Source:** Apple (moderator)

**Title:** Summary of [AT116bis-e][612][POS] Positioning accuracy enhancements (Apple)

**Document for:**  Discussion

# 1. Introduction

This document summarizes the following email discussion:

\* **[AT116bis-e][612][POS] Positioning accuracy enhancements (Apple)**

      Scope: Discuss the contributions in AI 8.11.7 on accuracy enhancements (excluding PRU topics).  Determine agreeable RAN2 spec impact from RAN1 conclusions and identify any issues requiring further RAN2 discussion.

      Intended outcome: Report to Monday CB session

      Deadline:  Friday 2022-01-21 1600 UTC

## 1.1 References

1. R2-2200297 Discussion on additional TRP beam/antenna information CATT discussion Rel-17 NR\_pos\_enh-Core
2. R2-2200299 Discussion on stage-2 impact of mitigating UE and TRP RxTx timing delays CATT discussion Rel-17 NR\_pos\_enh-Core
3. R2-2200300 Discussion on LPP and RRC signaling impact of mitigating UE and TRP RxTx timing delays CATT discussion Rel-17 NR\_pos\_enh-Core
4. R2-2200301 [Draft]Reply LS on the reporting of the Tx TEG association information CATT LS out Rel-17 NR\_pos\_enh-Core To:RAN1, RAN3 Cc:RAN4
5. R2-2200330 Discussion on accuracy enhancements vivo discussion Rel-17 NR\_pos\_enh-Core
6. R2-2200429 Discussion on accuracy enhancement Huawei, HiSilicon discussion Rel-17 NR\_pos\_enh-Core
7. R2-2200916 Considerations on Timing Error aspects Sony discussion Rel-17 NR\_pos\_enh-Core
8. R2-2201062 LPP Positioning enhancements on timing errors , DL-AoD and LoS/NLoS/multipath Ericsson discussion Rel-17
9. R2-2201104 Signalling impacts of RAN1 agreements on accuracy enhancements Apple discussion NR\_pos\_enh-Core
10. R2-2201189 Discussion on Accuracy Enhancements InterDigital, Inc. discussion Rel-17 NR\_pos\_enh-Core
11. R2-2201360 Discussion on accuracy improvement for UE-assisted DL-AOD positioning vivo discussion Rel-17 NR\_pos\_enh-Core
12. R2-2200527 Discussion on signalling support of RAN1 agreements ZTE discussion
13. R2-2201066 Beam/antenna information for DL AOD in NR positioning Ericsson discussion Rel-17

## 1.2 Contact Points

Respondents to the email discussion are kindly asked to fill in the following table.

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| --- | --- | --- |
| Company | Name | Email Address |
| Apple | Sasha Sirotkin | ssirotkin@apple.com |
| Intel | Yi Guo | yiguo@intel.com |
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# 2. Discussion

A note from the moderator:

The contributions submitted have varying levels of detail, ranging from high level proposals to detailed stage-3 TPs.

As the intention is to have at some agreeable TPs by the end of this meeting, the moderator proposes to conduct this email discussion in two phases:

1. collect comments on questions asked below (Deadline Wednesday 2022-01-19 1600 UTC)
2. discuss the TPs (Deadline Friday 2022-01-21 1600 UTC)

After the first deadline (Wednesday 2022-01-19 1600 UTC), based on the answers to the questions, the moderator will select TPs which will need to be revised in accordance with the consensus or the majority view. The TPs will then be discussed till the final deadline (Friday 2022-01-21 1600 UTC).

## 2.1 Assistance Data

In this section the moderator asks for feedback on all the proposals related to assistance data (for all the positioning methods).

### 2.1.1 Background

#### 2.1.1.1 TRP beam/antenna information

CATT in R2-2200297 [1] propose to enable the LMF to provide TRP beam/antenna information as assistance information by enhancing the IE NR-DL-AoD-RequestAssistanceData and NR-DL-AoD-ProvideAssistanceData LPP IEs.

Huawei in R2-2200429 [6] have a similar proposal, specifically for that information to include:

* A list of angles (AoD/AoA or ZoD/ZoA or a combination of AoD/AoA and ZoD/ZoA)
* Under each angle
  + A primary PRS resource ID that radiates the maximum power at the angle
  + A list of radiation power differences and PRS resource IDs at the angle indicating the power differences for the target PRS resources with respect to the primary PRS resource

Apple in R2-2201104 [9] propose to enhance LPP ProvideAssistanceData to convey TRP beam/antenna information.

Furthermore, ZTE in R2-2200527 [12] also have similar proposals, specifically:

* The signaling structure is for a specific TRP can be a two-dimensional chart, where each DL PRS and each angle is associated with a power value that is calculated relatively to a PRS resource with the highest power in the angle.
* The relative power can be provided per frequency layer per TRP per angle per PRS resource set

On a related note, Ericsson in R2-2201066 [13] propose to liaise RAN1 with questions about resolution of the angular grid. The moderator proposes to discuss the LS separately (see clause 2.5 below).

#### 2.1.1.2 TRP Tx TEG ID association with DL PRS resources

Huawei in R2-2200429 [6] propose to add a new field prs-TxTEG-ID-Info for the IE ReferenceTRP-RTD-Info and RTD-InfoElement to represent the association between PRS and Tx TEG.

Apple in R2-2201104 [9] also propose to enhance LPP ProvideAssistanceData and posSIB to convey the association information of DL PRS resources with TRP Tx TEG ID.

#### 2.1.1.3 PRS subset

Huawei in R2-2200429 [6] propose to add a field assocSubsetInfo for the IE NR-DL-PRS-Resource that includes a list of PRS resource IDs and optionally a DL PRS resource set ID.

Alternatively, Apple in R2-2201104 [9] point out that RAN1 haven’t made the selection between a subset of PRS resources for the purpose of prioritization of DL-AOD reporting, and boresight direction information and therefore they propose to discuss which option (a subset of PRS resources for the purpose of prioritization of DL-AOD reporting, and boresight direction information) of PRS resource reporting to support.

Furthermore, vivo in R2-2201360 [5] also propose to introduce a PRS resource subset list in NR-DL-PRS-Info and each PRS resource subset is identified by a resource subset ID.

#### 2.1.1.4 DL-AOD expected angle

Huawei in R2-2200429 [6] propose to enhance the assistance request/reponse messages to support DL angle search window as follows:

* NR-DL-AoD-RequestAssistanceData
  + Add a new field expectedAngleSearchWindowType to indicate whether expected DL-AoD/uncertainty or expected DL-AoA/uncertainty is desired.
* NR-DL-AoD-ProvideAssistanceData
  + Add a pair of new fields nr-DL-PRS-ExpectedAngle and nr-DL-PRS-ExpectedAngleUncertainty for the IE NR-DL-PRS-AssistanceDataPerTRP

There is also a similar proposal made by Apple in R2-2201104 [9], specifically to enhance LPP RequestAssistanceData to allow UE to request the expected angle value and uncertainty.

### 2.1.2 Discussion

**Question 2.1-1: Do you agree to enhance LPP assistance data signalling to allow UE to request and LMF to provide TRP beam/antenna information?**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| Company | Yes/No | Comments |
| Intel | Yes | Agree. But theRAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. |
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**Question 2.1-2: Do you agree to enhance LPP assistance data signalling to allow LMF to provide the association information of DL PRS resources with TRP Tx TEG ID?**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Intel | Yes | Agree. But theRAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. |
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**Question 2.1-3: Do you agree to also include the association information of DL PRS resources with TRP Tx TEG ID in posSIB?**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| Company | Yes/No | Comments |
| Intel | Yes | Agree. But theRAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. |
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**Question 2.1-4: Do you include the information about subset of PRS resources for the purpose of prioritization of DL-AOD reporting?**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| Company | Yes/No | Comments |
| Intel |  | Would be good to wait for RAN1 inputs. TheRAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. |
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**Question 2.1-5: Do you include the boresight direction information?**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| Company | Yes/No | Comments |
| Intel |  | Would be good to wait for RAN1 inputs. TheRAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. |
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**Question 2.1-6: Do you agree to enhance LPP assistance data signalling to allow UE to request and LMF to provide the expected angle value and uncertainty?**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| Company | Yes/No | Comments |
| Intel | Yes | Agreed in RAN1. But theRAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. |
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### 2.1.3 Conclusions

## 2.2 Measurements

In this section the moderator asks for feedback on all the proposals related to measurements, including LPP and RRC, (for all the positioning methods).

### 2.2.1 Background

#### 2.2.1.1 UE Rx/Tx timing delays

CATT in the TP for R2-2200300 [3] suggest that the association information of UL SRS resources for positioning with Tx TEGs is sent by a UE in UEAssistanceInformation. Furthermore, they propose:

* UE report of multi-RSTD per RxTEG in DL-TDOA in NR-DL-TDOA-MeasElement
* UE report of UE Rx TEG and UE RxTx TEG in Provide Location Information
* UE report multiple UE Rx-Tx time difference measurements per UE Rx TEG or per UE RxTx TEG to LMF

Furthermore, they propose to discuss the configurable periodicities and the maximum number of the change of TxTEG.

vivo in R2-2200330 [5] propose that:

* The gNB can request the UE to provide the association information of UL SRS resources for positioning with Tx TEGs by RRC message RRCReconfiguration.
* The UE can provide the association information of UL SRS resources for positioning with Tx TEGs to gNB by RRC message UEAssistanceInformation or a new RRC message.
* The LMF can request the UE to provide the association information of UL SRS resources for positioning with Tx TEGs by LPP message *RequestLocationInformation*.
* The UE can provide the association information of UL SRS resources for positioning with Tx TEGs to LMF by LPP message *ProvideLocationInformation*.
* the gNB can request the UE to report the Tx TEG association information between UE Tx TEG IDs and SRS resources periodically.

Huawei in R2-2200429 [6] propose to add:

* In IE NR-DL-TDOA-RequestLocationInformation
  + Request of Rx TEG ID for the report
  + The maximum number of Rx TEGs for the same PRS resource.
* In IE NR-DL-TDOA-MeasElement
  + Add a new field nr-DL-TDOA-AdditionalMeasurements to incorporate additional 28 measurements per TRP.
  + Add a new field rxTEG-ID for the IE NR-DL-TDOA-MeasElement and NR-DL-TDOA-AdditionalMeasurementElement to represent the Rx TEG ID associated with the RSTD measurement.
* In IE *NR-Multi-RTT-RequestLocationInformation*
  + Request of Rx TEG ID or RxTx TEG ID for the report.
  + Request of Tx TEG ID for the report.
  + The maximum number of Rx TEGs or RxTx TEG ID for the same PRS resource.
* In IE *NR-Multi-RTT-MeasElement*
  + Add a new field *nr-Multi-RTT-AdditionalMeasurements* for the IE to incorporate additional 28 measurements per TRP.
  + Add a new field *teg-ID-Info* for the IE *NR-Multi-RTT-MeasElement* and *NR-Multi-RTT-AdditionalMeasurementElement* forthe Rx TEG ID, RxTx TEG ID and Tx TEG ID associated with the UE Rx – Tx time difference measurement.
* In IE *NR-Multi-RTT-ProvideLocationInformation*
  + Add a new field *srs-TxTEG-ID-Info* for the association between SRS and Tx TEG.

Sony in R2-2200916 [7] argue that UE has the capability to report changes of TEG association in a timely manner.

Ericsson in R2-2201062 [8] propose:

* Rx TEG IDs shall be introduced for RSTD reference time and for each DL RSTD measurement in the UE DL-TDOA measurement report
* Introduce support for an LMF request and UE attributes to enable Rx TEG sweeping (measurement of DL timing over different UE Rx TEG IDs for the same DL-PRS)
* Rx TEG IDs shall be introduced for each DL measurement and Tx TEG IDs shall be introduced for UL-SRSs (two possible signalling options, UE->gNB->LMF or UE->LMF), and UE RxTx TEG IDs shall be introduced for the combined UL+DL TEGs

Apple in R2-2201104 [9] propose to enhance LPP ProvideLocationInformation to convey the following information: association of UL SRS for positioning resources with UE Tx TEGs ID, multiple RSTD measurements (for N different UE Rx TEGs), multiple UE Rx-Tx time difference measurements (for N different UE Rx TEGs), and multiple UE Rx-Tx time difference measurements (for N different UE RxTx TEGs with the same UE Tx TEG).

Furthermore, Apple argue that two signalling options (LPP and RRC+NRPPa) to convey the association of UL SRS resources with UE Tx TEGs ID are not needed and only one (e.g. LPP) is sufficient.

InterDigital in R2-2201189 [10] propose:

* UE reports association between UE Tx TEG and SRSp resource at periodically configured reporting occasion if there are any changes to the association compared to the previous association.
* Granularity of periodicity of transmission of the association report should be the same as that of SRSp transmission periodicity
* For UL-TDOA,UE reports updated association information between UE Tx TEGs and UL SRS resources for positioning to the serving gNB via RRC
* For DL-TDOA, when requested by the LMF, UE includes UE RX TEG ID in LPP Provide Location Information

ZTE in R2-2200527 [12] propose:

* For multi-RTT, the reported Tx TEG and SRS association relationship is directly sent to LMF in ProvideLocationInformation.
* For UL-TDOA, the association relationship is sent to serving gNB via RRC signalling, it can be embedded in *MeasResults.*
* When reporting SRS and Tx TEG association relationship for UL/UL+DL positioning, to indicate the change of the Tx TEG association during the configured period, each SRS resource can be associated with a list of {Tx TEG ID, time stamp}.

#### 2.2.1.2 DL AoD, Multipath

Huawei in R2-2200429 [6] propose to support UE to feedback whether the PRS is measured in the angle search window.

Ericsson in R2-2201062 [8] propose:

* To introduce support for an LMF request and UE attributes to enable first path PRS RSRP reporting for DL-AoD.
* To introduce support for extended additional paths (more than 2)
* To introduce support for a LoS/NLoS indication per RSTD, RSRP and UE RxTx measurements

Apple in R2-2201104 [9] propose to enhance LPP ProvideLocationInformation to convey DL PRS RSRPP (reference signal received path power).

### 2.2.2 Discussion

**Question 2.2-1: Do you agree to introduce in LPP RequestLocationInformation:**

**request for UE Rx TEG ID,**

**maximum number of Rx TEGs for the same PRS resource,**

**request for UE Tx TEG ID,**

**maximum number of Tx TEGs for the same PRS resource,**

**request for UE RxTx TED ID,**

**maximum number of RxTx TEGs for the same PRS resource.**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| Company | Yes/No | Comments |
| Intel | Yes | Agree. The RAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. |
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**Question 2.2-2: Do you agree to introduce in LPP ProvideLocationInformation: UE Rx TEG IDs, UE Tx TEG IDs, and UE RxTx TEG IDs?**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| Company | Yes/No | Comments |
| Intel | Yes | Agree. The RAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. |
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**Question 2.2-3: Do you agree to introduce in LPP ProvideLocationInformation: multiple UE Rx-Tx time difference measurements (for N different UE Rx TEGs), and multiple UE Rx-Tx time difference measurements (for N different UE RxTx TEGs with the same UE Tx TEG)? What is your preference for N?**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Intel | Yes | Agree. The RAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. N should wait for RAN1 decision. |
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**Question 2.2-4: Which signaling option you prefer for association of UL SRS resources with UE Tx TEGs ID:**

**Option a) RRC UEAssistanceInformation**

**Option b) New RRC message**

**Option c) RRCReconfigurationComplete**

**Option d) LPP ProvideLocationInformation**

**Consider providing your preference for signalling details for your favourable option in the comments column.**

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| Company | Yes/No | Comments |
| Intel | Option a or measurement report | RAN1 already agreed RRC approach as   * *For UL-TDOA, supporting the following for the serving gNB to request a UE to report the Tx TEG association information between UE Tx TEG IDs and SRS resources for positioning, subject to UE capability of supporting UE Tx TEG:*   RRC UE assistanceInforamtion or measurement report can be reused. |
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**Question 2.2-5: Do you agree to introduce support for an LMF to request and UE to report first path PRS RSRP for DL-AoD?**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| Company | Yes/No | Comments |
| Intel | Yes | Agree. RAN1 has agree it. The RAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. |
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**Question 2.2-6: Do you agree to introduce support for extended additional paths beyond 2?**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| Company | Yes/No | Comments |
| Intel | Yes | Agree. RAN1 has agree it. The RAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. |
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**Question 2.2-7: Do you agree to introduce support a LoS/NLoS indication per RSTD, RSRP and UE RxTx measurements?**

**If you answer yes and if you have a preference regarding signalling details, please provide those details in the comments column.**

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Intel | Yes | Agree. RAN1 has agree it. The RAN1 parameter lists in R1-2112976 should be used as baseline for RAN2 discussion on each features. |
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### 2.2.3 Conclusions

## 2.3 Capabilities

### 2.3.1 Background

vivo in R2-2200330 [5] propose that:

* The gNB can enquire UE’s capability of supporting multiple UE Tx TEGs for UL TDOA by RRC message UECapabilityEnquiry.
* The UE can report its capability of supporting multiple UE Tx TEGs for UL TDOA to the gNB by RRC message UECapabilityInformation.
* The LMF can enquire UE’s capability of supporting multiple UE Tx TEGs for Multi-RTT to the gNB by LPP message *RequestCapabilities*.
* The UE can report its capability of supporting multiple UE Tx TEGs for Multi-RTT to the LMF by RRC message *ProvideCapabilities*.

Ericsson in R2-2201062 [8] propose the following capability LPP signalling:

* UE capability indicating support for UE Rx TEG IDs for DL-TDOA
* UE capability indicating support for UE Tx TEG IDs for UL positioning
* UE capability indicating support for i) UE Tx TEG IDs and UE Rx TEG IDs, ii) UE RxTx TEG IDs for Multi-RTT positioning
* UE capabilities indicating support for LoS/NLoS indication

Apple in R2-2201104 [9] propose the following capability LPP signalling:

* The maximum number of UE RxTEGs [for UE-assisted DL TDOA and/or Multi-RTT]
* The maximum number of UE TxTEGs [for UL-TDOA and/or Multi-RTT]
* The maximum number of UE-RxTx TEGs
* Capability to provide the association information of UL SRS resources for positioning with UE Tx TEGs ID
* Capability to measure the same DL PRS resource with N different UE Rx TEGs and report the corresponding multiple RSTD measurements
* Capability to measure the same DL PRS resource with N different UE Rx TEGs and report the corresponding multiple UE Rx-Tx time difference
* Capability to measure the same DL PRS resource with N different UE RxTx TEGs with the same UE Tx TEG, and report the corresponding multiple UE Rx-Tx time difference measurements
* The maximum number of DL PRS RSRPP
* Capability to receive an indication for each PRS resource, of a subset of PRS resources for the purpose of prioritization of DL-AOD reporting
* Capability to receive an indication for each PRS resource, of the boresight direction information

### 2.3.2 Discussion

**Question 2.3-1: Do you agree to introduce support for multiple UE Tx TEGs for UL TDOA capability in RRC?**

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Intel |  | RAN1 is discussing UE feature lists. For these RAN1 led items, final capabilities shall be decided by RAN1. In general, we agree that we need to introduce TEG capability in RRC. |
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**Question 2.3-2: which of the following LPP capability signalling you agree to introduce?**

1. The maximum number of UE RxTEGs [for UE-assisted DL TDOA and/or Multi-RTT]
2. The maximum number of UE TxTEGs [for UL-TDOA and/or Multi-RTT]
3. The maximum number of UE-RxTx TEGs
4. Capability to provide the association information of UL SRS resources for positioning with UE Tx TEGs ID
5. Capability to measure the same DL PRS resource with N different UE Rx TEGs and report the corresponding multiple RSTD measurements
6. Capability to measure the same DL PRS resource with N different UE Rx TEGs and report the corresponding multiple UE Rx-Tx time difference
7. Capability to measure the same DL PRS resource with N different UE RxTx TEGs with the same UE Tx TEG, and report the corresponding multiple UE Rx-Tx time difference measurements
8. The maximum number of DL PRS RSRPP
9. Capability to receive an indication for each PRS resource, of a subset of PRS resources for the purpose of prioritization of DL-AOD reporting
10. Capability to receive an indication for each PRS resource, of the boresight direction information
11. Support for LoS/NLoS indication

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| Company | Yes/No | Comments |
| Intel |  | RAN1 is discussing UE feature lists. For these RAN1 led items, final capabilities shall be decided by RAN1. In general, we agree that we need to introduce TEG capability, LOS/NLOS in LPP. |
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### 2.3.3 Conclusions

## 2.4 Stage-2

### 2.4.1 Background

The following papers contain stage-2 TPs:

* CATT in R2-2200297 [1]
* CATT in R2-2200299 [2]
* Huawei in R2-2200429 [6]

### 2.4.2 Discussion

**Question 2.4-1: Please provide your comments on the following stage-2 TPs**

1. CATT in R2-2200297 [1]
2. CATT in R2-2200299 [2]
3. Huawei in R2-2200429 [6]

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Intel |  | R2-2200297 is for TRP beam/antenna information. In general it is ok. But for the information from gNB to the LMF, RAN1 left it to RAN3, we may change nothing depends on RAN3 decision.   * Note: up to RAN3 to decide how the TRP beam information is provided to the LMF for both UE-assisted and UE-based   R2-2200429 and R2-2200299 are both for TEG, and changed different sections. We can combine them together. |
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### 2.4.3 Conclusions

## 2.5 Other

### 2.5.1 Background

CATT in R2-2200300 [3] propose send an LS to RAN1 asking to delete the duplicated parameters, srs-PosResourceSetId associated with ueTxTEG-ID and update the value range of maxNumOfUE-RxTEG.

Ericsson in R2-2201066 [13] propose send an LS to RAN1 requesting about the resolution of the angular grid, in zenith and azimuth, over which the relative power of PRS Resources should be reported.

### 2.5.2 Discussion

**Question 2.5-1: Do you support sending LS to RAN1 asking to delete the duplicated parameters, srs-PosResourceSetId associated with ueTxTEG-ID and update the value range of maxNumOfUE-RxTEG, as proposed in R2-2200300 [3]**?

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Intel | Yes |  |
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**Question 2.5-2: Do you support sending LS to RAN1 requesting about the resolution of the angular grid, in zenith and azimuth, over which the relative power of PRS Resources should be reported as proposed in R2-2201066 [13]**?

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| Company | Yes/No | Comments |
| Intel | No | The issue should be discussed in RAN1 directly, but it is too late. RAN2 should avoid the duplicated discussion. |
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### 2.5.3 Conclusions

# 4. Proposed Conclusion

TBD

# 5. TPs

TBD