**3GPP TSG RAN WG1 Meeting #105-e R1-** **2105967**

**e-meeting, May 19th – 27th, 2021**

**Source: Moderator (CATT)**

**Title: FL Summary for accuracy improvements by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays**

**Agenda item: 8.5.1**

**Document for: Discussion and Decision**

# Introduction

This document provides a summary of the following email discussion for AI 8.5.1:

[105-e-NR-ePos-01] Email discussion/approval on accuracy improvements by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays with checkpoints for agreements on May 25, May 27 – Ren Da (CATT)

One of the RAN1 objectives of this work item is to:

* Specify **methods**, **measurements**, **signalling, and procedures** for improving positioning accuracy of the Rel-16 NR positioning methods by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays, including [RAN1]
  + DL, UL and DL+UL positioning methods
  + UE-based and UE-assisted positioning solutions

The document covers the following aspects related to potential enhancements related to the accuracy improvements by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays based on the contributions [1-19]:

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| 1. Definitions of UE/TRP Rx/Tx timing errors and Timing Error Groups 2. Methods for mitigating UE/TRP Tx/Rx timing errors    1. TRP Tx and UE Rx timing errors for DL TDOA    2. UE Tx and TRP Rx timing errors for UL TDOA    3. UE/gNB Rx/Tx timing errors in DL+UL positioning 3. Reference devices for mitigating UE/gNB Tx/Rx timing errors 4. Measurement enhancements for mitigating UE/gNB Tx/Rx timing errors 5. Additional proposals |

**Notes:**

* The following highlights will be used in this summary:
  + “Pink highlights” are used for proposals with high priority
  + “Yellow highlights” are used for proposals with medium priority
  + “Turquoise highlights” are used for offline consensus/conclusion
  + “Grey highlights” are used for proposals resolved in this meeting.

Note: The above priority highlights are used mainly as a suggestion of the priority for *online* discussion. The priority indications may be changed based on the received comments. During the email discussion, interested companies are encouraged to provide comments to all proposals regardless of the priority indications.

* When providing the comments, it would be helpful to indicate explicitly whether to“*support*”, or “*not support*”, or provide a suggestion of modification. A comment of “*high/medium/low priority*” is only interpreted as a suggestion for the priority for email/online discussions. For a proposal with multiple options, it would be helpful to indicate which of the option(s) are “*supported*” and/or “*preferred*”.
* For a proposed enhancement, if we cannot reach a consensus, we may conclude that “*a consensus cannot be reached for the proposed enhancement*” for this email discussion in this meeting. It does not necessarily mean the proposed enhancement will not be further discussed in future meetings.

# Definitions of UE/TRP Rx/Tx timing errors and Timing Error Groups

*Background*

The following agreement was made in RAN1#104e for the definitions of the UE/TRP Tx/Rx timing errors and UE/TRP Tx/Rx TEGs. The definitions were agreed upon for purpose of discussion of methods, measurements, signalling, and procedures for mitigating UE Rx/Tx and/or gNB Rx/Tx timing errors, but was not agreed to be included in the specifications yet.

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| Agreement:  The following definitions are used for the purpose of discussion of internal timing errors (these terms are not agreed to be included in the specifications):   * **Tx timing error**: From a signal transmission perspective, there will be a time delay from the time when the digital signal is generated at baseband to the time when the RF signal is transmitted from the Tx antenna. For supporting positioning, the UE/TRP may implement an internal calibration/compensation of the Tx time delay for the transmission of the DL PRS/UL SRS signals, which may also include the calibration/compensation of the relative time delay between different RF chains in the same TRP/UE. The compensation may also possibly consider the offset of the Tx antenna phase center to the physical antenna center. However, the calibration may not be perfect. The remaining Tx time delay after the calibration, or the uncalibrated Tx time delay is defined as *Tx timing error*. * **Rx timing error**: From a signal reception perspective, there will be a time delay from the time when the RF signal arrives at the Rx antenna to the time when the signal is digitized and time-stamped at the baseband. For supporting positioning, the UE/TRP may implement an internal calibration/compensation of the Rx time delay before it reports the measurements that are obtained from the DL PRS/UL SRS signals, which may also include the calibration/compensation of the relative time delay between different RF chains in the same TRP/UE. The compensation may also possibly consider the offset of the Rx antenna phase center to the physical antenna center. However, the calibration may not be perfect. The remaining Rx time delay after the calibration, or the uncalibrated Rx time delay is defined as Rx timing error. * **UE Tx ‘timing error group’ (UE Tx TEG):** A UE Tx TEG is associated with the transmissions of one or more UL SRS resources for the positioning purpose, which have the Tx timing errors within a certain margin. * **TRP Tx ‘timing error group’ (TRP Tx TEG):** A TRP Tx TEG is associated with the transmissions of one or more DL PRS resources, which have the Tx timing errors within a certain margin. * **UE Rx ‘timing error group’ (UE Rx TEG):** A UE Rx TEG is associated with one or more DL measurements, which have the Rx timing errors within a certain margin. * **TRP Rx ‘timing error group’ (TRP Rx TEG):** A TRP Rx TEG is associated with one or more UL measurements, which have the Rx timing errors within a margin. * **UE RxTx ‘timing error group’ (UE RxTx TEG):** A UE RxTx TEG is associated with one or more UE Rx-Tx time difference measurements, and one or more UL SRS resources for the positioning purpose, which have the ‘Rx timing errors+Tx timing errors’ within a certain margin. * **TRP RxTx ‘timing error group’ (TRP RxTx TEG):** A TRP RxTx TEG is associated with one or more gNB Rx-Tx time difference measurements and one or more DL PRS resources, which have the ‘Rx timing errors+Tx timing errors’ within a certain margin. |

## Antenna array phase center offset

Submitted Proposals

* (Nokia, [R1-2105512](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105512.doc)[14]) Proposal 1: UE to include reporting of gNB specific SRS-Pos TOD offsets to gNB/LMF for post-compensation of direction specific UE antenna phase center offsets thereby enhancing the positioning accuracy.
* (Nokia, [R1-2105512](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105512.doc)[14]) Proposal 2: UE to signal to gNB/LMF its capabiltiy to compensate for antenna phase center offsets for time based positioning. Note this could apply to both broad beam and narrow beam SRS-Pos transmissions.
* (Nokia, [R1-2105512](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105512.doc)[14]) Proposal 3: Include the impact of antenna PCO in the definition of RX/TX timing errors and associated TEGs
  + FL: Already considered in the Rx/Tx timing error/TEG definitions in my view.
* (Fraunhofer, [R1-2105856](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105856.doc) [17]) Proposal 1:
  + DL-PRS transmitted on the same FL and from the same ARP are associated with the same TEG.
  + The LMF in UE-Assisted mode and the UE in UE-Based mode can assume that DL-PRS resources transmitted from the same TRP ARP are associated with the same TEG.
* FL: Already considered in the Rx/Tx timing error/TEG definitions in my view.
* (Fraunhofer, [R1-2105856](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105856.doc) [17]) Proposal 2: For mitigating TRP Rx timing errors:
  + Support TRP to provide the LMF with ARP information related to the UL-SRS measurements (similar to the DL-PRS ARP information).
* (Fraunhofer, [R1-2105856](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105856.doc) [17]) Proposal 3: UL-SRS measurements received on the same FL from the same TRP-ARP are associated with the same Rx-TEG.
* FL: Already supported by the Rx/Tx timing error/TEG definitions in my view.
* (Fraunhofer, [R1-2105856](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105856.doc) [17]) Proposal 5: Support the UE providing the ARP information relative to a UE reference point using a UE coordinate system (UCS).

FL comments

The phase center offsets (PCOs) may be different for different antenna panels and different beam directions, which may result in different timing delays or time of departure (TOD) for different beam directions, and have an impact on the measurement and positioning accuracy. Due to the impact of the PCOs, the true coordinates of the antenna center for the RF signal Tx/Rx may be different from the physical antenna reference point (ARP) for different beams and different positioning frequency layers (PFLs). Similar to the Rx/Tx timing errors, the impact of the PCOs could be compensated if they are known. However, the transmitter and/or the receivers may or may not know the PCOs, and if compensated, there can be remaining errors after the calibration. The impact of PCOs as a part of timing errors and included into the definition of the Rx/Tx timing errors and TEGs (as shown in the definitions of the Tx/Rx timing error, i.e., ‘*The compensation may also possibly consider the offset of the Tx antenna phase center to the physical antenna center.’*). We may further discuss whether to provide additional information related to the PCOs/ARPs from UE/TRP to the LMF as proposed in [14][17].

### Proposal 2.1-1

* Further study whether there is a need to support the following enhancements related to phase center offsets (PCOs):
  + UE to include reporting of gNB specific SRS-Pos TOD offsets to gNB/LMF for post-compensation of direction-specific UE antenna phase center offsets.
  + UE to signal to gNB/LMF its capability to compensate for antenna phase center offsets for time-based positioning.
  + UE to provide the ARP (Antenna Reference Point) information relative to a UE reference point using a UE coordinate system (UCS).
  + TRP to provide the LMF with ARP information related to the UL-SRS measurements.

Comments

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| **Company** | **Comments** |
| OPPO | Not support since it is addressed by Rx/Tx TEG based solutions    In the definition of Tx timing error and Rx timing error, the phase center offsets have been included as below (Highlighted by Yellow):   * **Tx timing error**: From a signal transmission perspective, there will be a time delay from the time when the digital signal is generated at baseband to the time when the RF signal is transmitted from the Tx antenna. For supporting positioning, the UE/TRP may implement an internal calibration/compensation of the Tx time delay for the transmission of the DL PRS/UL SRS signals, which may also include the calibration/compensation of the relative time delay between different RF chains in the same TRP/UE. The compensation may also possibly consider the offset of the Tx antenna phase center to the physical antenna center. However, the calibration may not be perfect. The remaining Tx time delay after the calibration, or the uncalibrated Tx time delay is defined as *Tx timing error*. * **Rx timing error**: From a signal reception perspective, there will be a time delay from the time when the RF signal arrives at the Rx antenna to the time when the signal is digitized and time-stamped at the baseband. For supporting positioning, the UE/TRP may implement an internal calibration/compensation of the Rx time delay before it reports the measurements that are obtained from the DL PRS/UL SRS signals, which may also include the calibration/compensation of the relative time delay between different RF chains in the same TRP/UE. The compensation may also possibly consider the offset of the Rx antenna phase center to the physical antenna center. However, the calibration may not be perfect. The remaining Rx time delay after the calibration, or the uncalibrated Rx time delay is defined as Rx timing error. |
| Fraunhofer | Support.  To OPPO, the comment is not clear because the definition of the TEGs and timing errors are not supposed to be changed with this proposal. In addition, the WI target UE and/or gNB Rx/Tx timing delays: the order of error due to unkown ARP information will exceed Rel-17 accuracy requirements!  To calrify: For the first two bullets the phase offsets for the different beams may be compensated by the UE and a common antenna reference point within a margin (as highlighted by OPPO). The capability to compensate this margin and information on the erorr margin can be provided as part of the Tx/Rx timing error.  For the third and fouth bullet the offset between the antenna (or beam) reference points from the different ARPs is high. For DL-PRS the TRP-ARP issue is already addressed in Rel-16. |
| CATT | We prefer to treat it as low priority. |
| vivo | Not support |
| Huawei, HiSilicon | We consider it low priority given the PCO of the UE is “direction specific”. There could be no way to know the PCO if UE has no idea from which direction each RP is located. |
| Qualcomm | Low priority |
| Apple | Not support, we share similar view as OPPO and HW/HiSi |
| Nokia/NSB | Support. Especially the 2nd bullet is important in our view. If the network doesn’t know if the UE is taking into account the PCO impact then it may not know if the TEGs are valid for certain measurements.  To OPPO, we agree that the definition of timing errors already has PCO impacts included and that the solutions being agreed for TEG can potentially also apply to the PCO problem. However, we feel that some additional care should be taken to make sure that the TEG concept can appropriately take care of this issue. We are open to discussing further.  To Huawei, the UE may know the direction of the TRP based on DL signals (e.g., in multi-RTT). |
| SONY | We don’t support the direction-specific UE antenna PCOs for two reasons. First, we doubt the feasibility of a UE measuring multiple PCOs at different beams. Secondly, the difference of the PCOs at different beams is relatively small because the UE has limited number of RF chain. Hence, all the UE beams typically share the same RF chain.  For the panel-specific UE antenna PCOs, we think it can be handled by the Rx/Tx TEG based solutions as OPPO suggested. Firstly if the PCOs are known by UE, the UE can merge it into the TEG. Then, to address the multiple panel PCOs, UE can use association information to identify the TEGs (containing PCOs) at different panels. |
| LG | Not support, we have similar view with OPPO, HW/HiSi and SONY. |

## Definition of UE Rx-Tx time difference measurements

Submitted proposals

* (Qualcomm, [R1-2104671](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104671.doc)[6]) Proposal 1: Include in the UE Rx-Tx measurement report, at least an UL timestamp which corresponds to the uplink subframe used by the UE to derive the TUE-TX timing in the UE Rx-Tx measurement. Change the TUE-TX UE Rx-Tx definition as follows:
  + TUE-TX is the UE transmit timing of uplink subframe #j in which the transmission of the associated SRS resource was scheduled according to the UE’s report.

FL comments

With the current definition in TS 38.215, a UE determines the UE Rx – Tx time difference based on the reception time of the DL PRS and UL Tx time of the closest UL subframe, but it does not require UL SRS to be transmitted at the closest UL subframe. If we want to address the concern from Qulacomm, then there is at least to add the mod operation into the definition since the value range of UE Rx – Tx time difference does not exceed 1ms.

### Proposal 2.2-1

* In the UE Rx-Tx measurement report, include a timestamp that corresponds to the uplink subframe used by the UE to derive the TUE-TX timing in the UE Rx-Tx measurement, and make the following modifications to the UE Rx-Tx time difference definition:
  + UE Rx – Tx time difference is defined as mod(TUE-RX –TUE-TX, 1ms)

The UE Rx – Tx time difference is defined as mod(TUE-RX –TUE-TX, 1ms)

Where:

TUE-RX is the UE received timing of downlink subframe #*i* from a Transmission Point (TP) [18], defined by the first detected path in time.

TUE-TX is the UE transmit timing of uplink subframe #*j* ~~that is closest in time to the subframe #i received from the~~ ~~TP~~ for the transmission of the associated SRS resource.

Comments

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| **Company** | **Comments** |
| OPPO | Some question for clarification  1. In TS 37.355, there is a timestamp associated with UE Rx-Tx measurement. Is the intention of this proposal to introduce an new timestamp, or change the definition of this timestamp (e.g., the time instance for which the measurement is performed -> the uplink subframe used by the UE to derive the TUE-TX timing in the UE Rx-Tx measurement) ? Is there any change regarding timestampe for gNB Rx-Tx Time Difference accordingly?  2. If we can agree some update/change on the UE Rx – Tx time difference, would it be better for R16 rather than R17? |
| vivo | No needed. From our understanding, UE Rx-Tx time difference measurement is DL measurement independent of actual SRS transmission. For example, there are multiple SRS occasions around one PRS measurement. If the Rx-Tx measurement is associated with the actual SRS transmisson, which SRS occasion will be selected? |
| CATT | We prefer to treat it as low priority. |
| Huawei, HiSilicon | Just to clarify if the change discussed here is about changing Rel-16 spec or Rel-17 only. |
| Qualcomm | High priority  To vivo: The measurement is still independent of the SRS transmission. The UE includes at which time the “T\_Tx” was derived and used for reporting. It is UE’s responsibility to pick a good UL timestamp. In the worst case, it will pick exactly the same as in rel-16 (aka the subframe that is closest in time to the DL PRS from that TRP). However, we believe, as we explain in the tdoc, that we can enhance the performance if we allow the UEs to include a timestamp that corresponds to when the “T\_Tx” was derived.  To OPPO: It is an additional time-stamp. Currently the timestamp is really the time of the PRS reception.  We are OK to change it for Rel-17 only, and not go back to rel-16 sicne it is an RRC change. If the UE does not repor the new timestamp, the assumption is that the T\_TX is the same as in Rel-16, so the solution defaults to the rel-16 solution. |
| Nokia/NSB | We are okay to change this for Rel-17 only. |

## Inter-TRP timing error

Submitted Proposals

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 1: The issues of ‘inter-TRP timing error’ in DL-TDOA/UL-TDOA method should be clarified.
  + e.g., whether to regard ‘inter-TRP timing error’ as synchronization error beween TRPs.

FL Comments

* My understanding is the enhancement purely for the purpose of network synchronization is not within the scope of this WI. However, we may not want to exclude the enhancements for mitigating UE/TRP Tx/Rx that also have the side benefits of mitigating the impact of the network synchronization errors.

Comments

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| **Company** | **Comments** |
| Fraunhofer | Agree with the FL comment |
| CATT | Agree with the FL comments. |
| Ericsson | We object to this proposal. This is out of scope from the work item. |
| Nokia/NSB | Agree with FL comments. |
| SONY | Support FL comments |

# Methods for mitigating UE/TRP Tx/Rx timing errors

Background

## TRP Tx timing errors and/or UE Rx timing errors for DL TDOA

Background

The following conclusion was made in RAN1#104e, related to the option(s) for mitigating TRP Tx timing errors and/or UE Rx timing errors for DL TDOA.

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| Conclusion (RAN1#104-e):  Study the following options for mitigating TRP Tx timing errors and/or UE Rx timing errors for DL TDOA:   * Option 1:   + Support a TRP to provide the association information of DL PRS resources with Tx TEGs to LMF * Option 2:   + Support LMF to provide the association information of DL PRS resources with Tx TEGs to UE for UE-based positioning * Option 3:   + Support a TRP to provide the Tx timing errors per Tx TEG to LMF * Option 4:   + Support LMF to provide the Tx timing errors per Tx TEG of TRP to a UE for UE-based positioning * Option 5:   + Support a UE to provide the association information of RSTD measurements with UE Rx TEG(s) to LMF when the UE reports the RSTD measurements to LMF * Option 6:   + Support LMF to provide Rx timing errors per Rx TEG to a UE for UE-based positioning * Option7:   + Support a UE to provide Rx timing errors per Rx TEG to LMF for UE-assisted positioning * Option 8:   + Support a TRP to provide the Tx timing error differences between Tx TEGs of the TRP to LMF * Option 9:   + Support LMF to provide the Tx timing error differences between Tx TEGs of a TRP to a UE for UE-based positioning * Option10:   + Support a UE to provide Rx timing error differences between Rx TEGs to LMF for UE-assisted positioning * FFS: details of the signalling, procedures, and UE capability * FFS: How the TEGs are determined by the UE or TRP (could be by implementation, i.e., no specification impact) * Note: Other options are not precluded. * Note: Depending on the discussion results, none/one/multiple of the above options may be adopted in Rel-17.   Agreement: (RAN1#104bis-e)   * Support the following for mitigating TRP Tx timing errors and/or UE Rx timing errors for DL TDOA   + Support a UE to provide the association information of RSTD measurements with UE Rx TEG(s) to the LMF when the UE reports the RSTD measurements to the LMF if the UE has multiple TEGs   + Support a TRP providing the association information of DL PRS resources with Tx TEGs to the LMF if the TRP has multiple TEGs   + Support the LMF to provide the association information of DL PRS resources with Tx TEGs to a UE for UE-based positioning if the TRP has multiple TEGs   + FFS: the details of the signalling, procedures, and UE capability * Send an LS to RAN4 to check if there is any issue to support the above enhancements |

Submitted proposals and FL comments (specific for DL positioning)

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 2: The UE can be requested to provide the association information of RSTD measurements with UE Rx TEG(s) to LMF.

FL: The proposal seems already agreed in RAN1#104bis-e.

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 4: In DL-TDOA method, to eliminate the positioning error caused by the UE Rx timing errors of more than one UE Rx TEGs, the RSTD measurement report of a certain TRP for more than one UE Rx TEGs needs to be guaranteed if the UE is able to measure PRS(s) associated with different UE Rx TEGs.
  + FFS the UE reporting rules to guarantee the RSTD measurement report for more than one UE Rx TEGs.

FL: Discussed in previous meeting w/o conclusion. Suggest further discussion in Proposal 3-1.3.

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 3: When the UE is able to measure PRS(s) from a TRP associated with different UE Rx TEGs, support the UE to report original RSTD measurements (uncompensated measurements) and related Rx TEGs information to the LMF, rather than compensating ‘Rx timing error difference’ by UE implementation and then reporting compensated RSTD measurements to the LMF.

FL: Suggest further discussion in Proposal 3-1.3.

* (CATT, [R1-2104520](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104520.doc)[3]) Proposal 11: For UE-assisted DL-TDOA positioning, the following two methods should also be supported to help LMF eliminate the influence of timing errors of TRPs and UE:
* *Provide LMF with the Tx timing errors per Tx TEG.*

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| DL-TDOA | From | To | Signalling for mitigating TRP Tx timing errors |
| Option 3 | TRP | LMF | Tx timing errors per Tx TEG of TRP |

* *Provide LMFwith the Tx timing error differences between Tx TEGs.*

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| DL-TDOA | From | To | Signalling for mitigating TRP Tx timing errors |
| Option 8 | TRP | LMF | Tx timing error differences between Tx TEGs of the TRP |

FL: The options were discussion in previous meeting w/o conclusion. Suggest further discussion in 3.1-6.

* (CATT, [R1-2104520](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104520.doc)[3]) Proposal 12: For UE-based DL-TDOA positioning, the following two methods should also be supported to help UE eliminate the influence of timing errors of TRPs:
* ***Provide UE with the Tx timing errors per Tx TEG.***

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| **DL-TDOA** | **From** | **To** | **Signalling for mitigating TRP Tx timing errors** |
| Option 4 | LMF | UE | Tx timing errors per Tx TEG of TRP |

* ***Provide UE with the Tx timing error differences between Tx TEGs.***

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| **DL-TDOA** | **From** | **To** | **Signalling for mitigating TRP Tx timing errors** |
| Option 9 | LMF | UE | Tx timing error differences between Tx TEGs of a TRP |

FL: The options were discussed in the previous meeting w/o a conclusion. Suggest further discussion in 3.1-6.

* (Qualcomm, [R1-2104671](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104671.doc)[6]) Proposal 3: For UE-based DL-TDOA, support a UE receiving the Tx-TEG information for each PRS resource in the unicast or broadcast assistance data.

FL: See Proposal 3.1-4 for further discussion

* (OPPO, [R1-2104739](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104739.doc)[7]) Proposal 2: Rel-17 supports UE to report the grouping of DL TDOA measurement results via LPP for the implicit indication of UE Rx TEG information.

FL: Suggest the details of LPP be discussed in RAN2..

* (OPPO, [R1-2104739](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104739.doc)[7]) Proposal 3: Rel-17 supports LMF to signal the grouping of DL PRS resources to UE via LPP for the implicit indication of TRP Tx TEG information.

FL: Suggest the details of LPP be discussed in RAN2.

* (OPPO, [R1-2104739](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104739.doc)[7]) Proposal 4: Rel-17 supports gNB to signal the grouping of DL PRS resources to LMF via NRPPa for the implicit indication of TRP Tx TEG information.

FL: Suggest the details of LPP be discussed in RAN2.

* (InterDigital, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[8]) Proposal 7: For DL TDOA, support the LMF to indicate which Rx TEG(s) to use for the reception of one or more DL-PRS resources.

FL: LMF may not know which UE Rx beam can receive which DL-PRS resources. Suggest further discussion (Proposal 3.1-5).

* (Apple, [R1-2105105](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105105.doc)[10]) Proposal 4: At least for UE-assisted method, UE may be indicated by LMF to perform measurements corresponding to both DL-TDOA and DL-AoD positioning techniques
  + The measurements at least include DL-RSTD together with DL-PRS-RSRP over a set of (TRPs, antenna panels, PRS configurations, etc)
  + Additional UE capabilities may be needed

FL: In my opinion, “UE may be indicated by LMF to perform measurements corresponding to both DL-TDOA and DL-AoD positioning techniques” is already supported. TRPs and PRS configurations are already provided in the assistance data. About the antenna panel, LMF may not have the information related to the TRP antenna panel.

* (Sony, [R1-2105168](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105168.doc)[11]) Proposal 1: In DL-TDOA positioning,
  + If UE is aware its own Rx timing error, support UE to provide UE Rx timing errors associated with the RSTD measurements to the LMF.
  + If UE is not aware its own Rx timing error, support UE to provide the ID/index of the UE Rx TEG that is associated with the RSTD measurements to the LMF if the UE has multiple TEGs.
  + If TRP is aware of its own Tx timing errors, support TRP to provide the TRP Tx timing errors associated with the DL PRS resources to the LMF.
  + If TRP is not aware of its own Tx timing errors, support TRP to provide the ID/index of the TRP Tx TEG that is associated with the DL PRS resources to the LMF if the TRP has multiple TEGs.
  + If LMF knows TRP Tx timing errors, support the LMF to provide the TRP Tx timing errors associated with the DL PRS resources to a UE for UE-based positioning.
  + If LMF doesn’t know TRP Tx timing errors, support the LMF to provide the ID/index of TRP Tx TEG associated with the DL PRS resources to a UE for UE-based positioning.

FL: The options were discussed in the previous meeting w/o a conclusion. Suggest further discussion in 3.1-6.

* (Samsung, [R1-2105310](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105310.doc))[12]) Proposal 1: For DL-TDOA, UE could report the association information of Rx TEGs associated with RSTD measurements to LMF in the IE like NR-DL-TDOA-SignalMeasurementInformation.

FL: It was agreed that UE could report the association information of Rx TEGs associated with RSTD measurements to LMF. Which IE is used may be better discussed in RAN2.

* (Samsung, [R1-2105310](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105310.doc))[12]) Proposal 2: For indication of TEG in DL-TDOA method, one single reference TEG plus the TEG differences (in case of multiple different TEGs) can be considered.

FL: Unclear how the TEG differences work. Maybe it means the measurements without TEG ID have the default TEG ID, and rest has the additional TEG ID. If this is the case, this kind of detail in message formatting can be discussed in RAN2.

* (MTK, [R1-2105759](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105759.doc)[16]) Proposal 3-1: UE may report the DL-RSTD between the observed PRS resources within a same TX TEG of a TRP, to assist the TRP to calibrate the transmission timing offset between resources

FL: Suggest further discussion in Proposal 3-1.3.

* (MTK, [R1-2105759](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105759.doc)[16]) Proposal 3-2: UE may report the DL-RSTD between the observed PRS resources across TX TEGs of a TRP, to assist the TRP to calibrate the transmission timing offset between different TX TEGs of a TRP

FL: Suggest further discussion in Proposal 3-1.3.

* (MTK, [R1-2105759](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105759.doc)[16]) Proposal 3-3: The inter-TRP transmission timing difference could be measured by the reference UE. Same measurement reporting as the normal UEs is expected. LMF may handle the extraction of the inter-TRP transmission timing difference from the measurement reports

FL: Suggest further discussion in Proposal 3-1.3.

* (MTK, [R1-2105759](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105759.doc)[16]) Proposal 3-4: It is subject to UE capability for the reporting of DL-RSTD between a pair of RX TEGs under the measurement of same TRP’s signal

FL: Suggest further discussion in Proposal 3-1.3.

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 1 Support a UE to provide the association information of RSTD measurements with UE Rx TEG(s) for both the target and the reference TRP to the LMF when the UE reports the RSTD measurements to the LMF if the UE has multiple TEGs

FL: This proposal seems to be a simple clarification of the previous agreement. Further discussion in Proposal 3.1-2.

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 2 Support a UE to perform multiple RSTD measurements towards the same TRP utilizing different UE RX TEGs and to report these measurements to the LMF.

FL: Suggest further discussion in Proposal 3-1.3.

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 3 RAN1 to study further under what circumstances the UE should be capable of performing multiple RSTD measurements towards the same TRP utilizing different UE RX TEGs, e.g. if measurements utilizing different UE RX TEGs (i.e. UE antenna panels) can be performed based on 1) different DL PRSs transmitted from the same TRP, 2) different symbols of the same DL PRS, 3) different repetitions of the same DL PRS, 4) different occasions of the same DL PRS, 5) different DL PRSs transmitted from the same TRP, and/or 6) simultaneous reception of the same DL PRS.

FL: Suggest further discussion in Proposal 3-1.3.

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 19 Timing errors per UE/gNB RX/TX TEG should not be signalled by the UE/gNB to the LMF, nor from the LMF to the UE.

FL: Suggest further discussion in Proposal 3.2-6.

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 20 Timing errors differences between UE/gNB RX/TX TEGs should not be signalled by the UE/gNB to the LMF, nor from the LMF to the UE.

FL: Suggest further discussion in Proposal 3.2-6.

FL additional comments

It was agreed in RAN1#104bis-e that for DL TDOA, support

* UE to provide the association information of RSTD measurements with UE Rx TEG(s) to the LMF when the UE reports the RSTD measurements to the LMF if the UE has multiple TEGs;
* TRP to provide the association information of DL PRS resources with Tx TEGs to the LMF if the TRP has multiple TEGs
* LMF to provide the association information of DL PRS resources with Tx TEGs to a UE for UE-based positioning if the TRP has multiple TEGs

In this meeting, there are some additional proposals related to how the association information is provided:

For supporting DL-TDOA, multiple options were agreed to be studied in RAN1#104e, but only some of them were agreed to be supported in RAN1#104bis-e. In this meeting, there are still proposals to support/not support these options. For example, in [3], CATT proposes to support the following Option 3, Option 8, Option 4, and Option 9 for UE-assisted DL-TDOA positioning. In [6], Qualcomm proposes in addition an average timing error associated with a TEG ID for mitigating timing errors in DL-TDOA, UL-TDOA or DL+UL Positioning; in [11], Sony proposes to UE/TRP/LMF to report UE Rx/TRP Tx/LMF timing errors if the information is available; and in [19], Ericsson proposes not to support signaling timing errors per UE/gNB RX/TX TEG and Timing errors differences between UE/gNB RX/TX TEGs.

In [6], Qualcomm proposes to support a UE receiving the Tx-TEG information for each PRS resource in the unicast or broadcast assistance data for UE-based DL-TDOA.

For a Tx TEG, it seems the common view is that a Tx TEG is associated directly with the PRS/SRS resource(s)/resource set(s). It is also clear that one TRX Tx TEG can be associated with one or more DL PRS resources.

For an Rx TEG, there are different views on how to indicate the association. One approach is to explicitly associate an Rx TEG ID with the measurement. With this approach, there may a need to include Rx TEG ID for each measurement (or a group of the measurements) in each measurement report, and there can be two Rx TEG IDs associated with one RSTD measurement since the UE may use different Rx TEG for receiving the DL PRSs from the reference TRP and target TRPs. Another approach is to provide the association of the received PRS/SRS resources/resource sets with the Rx TEG. The Rx TEG ID of the measurements is then obtained implicitly from the received PRS/SRS resources/resource sets associated with the measurements. In this approach, the UE/TRP does not need to provide the Rx TEG ID for each measurement or in each measurement report. After the association of Rx TEG ID with the received PRS/SRS resources is provided, it does not need to be sent again until there is a need to update or reset.

If UE can use different UE Rx TEGs to measure the same DL PRS resource or different DL PRS resources from the same TRP Tx TEG, the time differences between these UE Rx TEGs may be obtained. If UE can use the same UE Rx TEGs to measure the DL PRS resources from the difference Tx TEG of the same TRP, the time differences between these TRP Tx TEGs may be obtained. This information may be useful for the LMF to improve the positioning performance as proposed in [2][16][19].

### Proposal 3.1-1 (H)

* Support one of the following options for DL TDOA if a UE has multiple Rx TEGs:
  + Option 1:
    - UE provides the association information of DL PRS resources (DL PRS resource sets) with Rx TEGs to the LMF;
    - Note: The association information may not need to be provided for each DL measurement report
  + Option 2:
    - UE includes two Rx TEG IDs associated with a DL RSTD measurement in each DL measurement report;
      * One Rx TEG ID associated with the DL PRS of the RSTD reference;
      * One Rx TEG ID associated the other DL PRS of the RSTD measurement;
      * Note: The two Rx TEG IDs can be the same.

Comments

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| **Company** | **Comments** |
| ZTE | We prefer option 2. the sub-bullets of option 2 seem not clear, we suggest to change like this:   * + Option 2:     - UE includes two Rx TEG IDs associated with a DL RSTD measurement in each DL measurement report;       * One Rx TEG ID associated with the DL PRS of the RSTD reference TRP;       * One Rx TEG ID associated the other DL PRS of the RSTD ~~measurement~~ neighbor TRP;       * Note: The two Rx TEG IDs can be the same. |
| OPPO | 1. For Option 2, there is no need to report the Rx TEG associated with Reference TRP for each measurement. A Rx TEG associated to reference TRP is sufficient (please refer to Proppsal 3.1-2)  2. what’s the difference between option 1 and option 2? From my understanding, option 2 and option 1 are similar from the perspective of signaling. For example, Rx TEG ID would be an optional field for Option 2. If this filed is not reported and the lastest association of PRS resources and Rx TEGs is assumed to be maintained, then Option 2 is the same as Option 1.  3. Reporting Rx TEG IDs for each PRS resources / RSTD measurement may lead to higher signaling overhead. Another way is to avoid the explicit reporting of Rx TEG IDs and report mupltiple group of the measurements in a report, where each group of the measurement is related to a Rx TEG implicitly. |
| Fraunhofer | Support Option 2, the TEG information in Option2 may be usefull at the LMF for common TEGs with UE-Rx-Tx and RSTD measurments. Is the TEG-ID common over measurements at different times? |
| CATT | We support Option 1. |
| vivo | We think it is more suitable to associate Rx TEG ID with DL RSTD measurement. Consider this case: UE has 2 Rx TEGs and different Rx TEGs are associated with different measurements from the same PRS resource, if UE only provides the association information of PRS resources, it is still unclear which measurement corresponds to which Rx TEG.  Besides, the following agreement has reached in RAN1 104b-e, it supports providing the association information of RSTD measurements with UE Rx TEG(s) other than the association information of DL PRS resources (DL PRS resource sets) with UE Rx TEG(s)   |  | | --- | | Agreement:   * Support the following for mitigating TRP Tx timing errors and/or UE Rx timing errors for DL TDOA   + - Support a UE to provide the association information of RSTD measurements with UE Rx TEG(s) to the LMF when the UE reports the RSTD measurements to the LMF if the UE has multiple TEGs | | * + - FFS: the details of the signalling, procedures, and UE capability |   In addition, for option2, we don’t think the Rx TEG ID(s) associated with the RSTD reference should be reported for each DL RSTD measurement since the Rx TEG ID(s) of reference PRS for each RSTD is the same and included in the measurement of ‘the reference PRS’ . So some modifications as follows   * + Option 2:     - UE includes ~~two~~ Rx TEG IDs associated with a DL RSTD measurement in each DL measurement report;       * ~~One Rx TEG ID associated with the DL PRS of the RSTD reference;~~       * One Rx TEG ID associated the ~~other~~ DL PRS of the RSTD measurement;       * ~~Note: The two Rx TEG IDs can be the same~~. |
| Ericsson | We are supportive of option 2, but think it could be reformulated a bit. A DL TDOA measurement report (i.e. the NR-DL-TDOA-SignalMeasurementInformation IE) contains one reference DL PRS used for all RSTD measurements towards different TRPs in the report. Thus, better to write:   * + Option 2:     - UE includes one reference TRP Rx TEG ID associated with the RSTD reference in a DL TDOA measurement report and one target TRP Rx TEG ID for each DL RSTD measurement in a DL TDOA measurement report;       * One Rx TEG ID associated with the DL PRS of the RSTD reference in the DL TDOA measurement report;       * One Rx TEG ID for each RSTD measurement in the DL TDOA report, associated with the target DL PRS of the RSTD measurement;       * Note: The two Rx TEG IDs can be the same.   We note that option 1 doesn’t give any timing error mitigation gains since the TEG of the reference isn’t given. |
| Huawei, HiSilicon | We do not think the Option 2 is necessary as presented in the email discussion last meeting.  For the reference TRP, there should be a first Rx TEG reported for the reference timing, and the for the non-reference TRP, there would be a second Rx TEG reported for the RSTD measurement relative to the reference timing associated with the first Rx TEG.  For more advanced reporting, if for a TRP (reference or non-reference TRP), multiple Rx timing can be derived using different Rx TEG, which should be fine, it can be supported by enhancing the additional timing reporting adopted in Rel-16, but the principle of a single reference timing based on a single Rx TEG should be followed.  Option 1 is already supported in our understanding based on the agreement in RAN1#104b, but why do we need the Note? |
| Qualcomm | The following agreement says that we report RxTEG associated to RSTD measurement, not PRS resources. An RSTD measurement can also be associated with a PRS resource ID (already specified).   |  | | --- | | Agreement:   * Support the following for mitigating TRP Tx timing errors and/or UE Rx timing errors for DL TDOA   + - Support a UE to provide the association information of RSTD measurements with UE Rx TEG(s) to the LMF when the UE reports the RSTD measurements to the LMF if the UE has multiple TEGs |   So, not sure what we are trying to clarify here. The above agreement would mean that the UE will report an RxTEG for the reference TRP and then an RxTEG for each RSTD. |
| Apple | Our understanding of what we agreed in 104b, based on “if the UE has multiple TEGs”, is something similar to Option 2, that is UE only reports delta Rx TEG to the reference PRS reception, and UE does not need to report TEG associated to RSTD measurement if there is single RX TEG, OR RxTEG for reference PRS and the other PRS reception is the same. BTW, we need to have a similar proposal for TRP… |
| Nokia/NSB | Same understanding as QC. We are not sure what this agreement brings on top of the prior agreement. |
| SONY | Same understanding as QC |
| CMCC | We share similar views with QC. |
| ZTE2 | To OPPO: *NR-DL-TDOA-SignalMeasurementInformation* in 37.355 doesn’t contain PRS resources in the reference TRP, because in R16, all PRSs in the reference TRP own the same reference timing, so it is not necessary to report additional PRS information in the reference TRP. Actually in R17, different PRSs in the reference TRP maybe received through different UE Rx TEGs. So we think it is necessary for UE to report its Rx TEG information of reference PRSs in the reference TRP. |
| Samsung | Similar view as QC, this proposal has been captured before. |
| LG | Agree with QC’s comment. |
| InterDigital | In the last meeting, we agreed that the UE provides the Rx TEG information when the UE reports the RSTD measurement. From our perspective, the UE does not need to always provide TEG information in each RSTD measurement report. For example, when the UE uses the same set of Rx TEGs for RSTD measurement compared to the last measurement report, REG information may not necessary.  **Therefore, we support Option 2 with the following modification:**   * + Option 2:     - UE optionally includes ~~two~~ Rx TEG ID(s) associated with a DL RSTD measurement in each DL measurement report;       * One Rx TEG ID associated with the DL PRS of the RSTD reference;       * One Rx TEG ID associated the other DL PRS of the RSTD measurement;       * Note: The two Rx TEG IDs can be the same.       * FFS when to include Rx TEG information. |
| ZTE3 | After a second thought, we agree with VIVO’s modification that only one Rx TEG per RSTD measurement is required. We suggest to add another note based on vivo’s version:   * + Option 2:     - UE includes ~~two~~ a Rx TEG ID~~s~~ associated with a DL RSTD measurement in each DL measurement report;       * ~~One Rx TEG ID associated with the DL PRS of the RSTD reference;~~       * ~~One Rx TEG ID associated the other DL PRS of the RSTD measurement;~~       * ~~Note: The two Rx TEG IDs can be the same~~.       * Note: the Rx TEG ID is associated with the TRP in each *NR-DL-TDOA-MeasElement* |

### Proposal 3.1-2 (H)

* Support a UE to provide the association information of RSTD measurements with UE Rx TEG(s) for both the target and the reference TRPs to the LMF when the UE reports the RSTD measurements to the LMF if the UE has multiple TEGs

Comments

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| **Company** | **Comments** |
| ZTE | ‘target TRP’ is not clear. If it describes the TRPs involved in the measurement, we think this proposal is almost the same as proposal 3.1-1 option 2. |
| OPPO | In our understanding, the proposal is to report an Rx TEG for *dl-PRS-ReferenceInfo* and an Rx TEG for each NR-DL-TDOA-MeasElement. If it is the correct understanding, Proposal 3.1-2 is the same as Option 2 of Proposal 3.1-1, and they can be merged. |
| Fraunhofer | Agree with Oppo, this can be achieved with Option2 in Proposal 3.1-1. |
| CATT | Support. |
| Ericsson | We are supportive of this proposal but this is captured by proposal 3.1-1 option 2. See also our comment to that proposal. |
| Huawei, HiSilicon | Unclear about the relationship between this proposal and Option 1 in Proposal 3.1-1. |
| Qualcomm | This is Related to Proposal 3.1-1 and can be treated together. Yes our understanding is that the UE will report an RxTEG for the reference TRP, and an RxTEG for each RSTD. |
| Apple | The intention of proposal needs further clarification, given that we have P3.1-1, which is more complete for discussion to us. |
| Nokia/NSB | Same understanding as QC. |
| CMCC | We have the same understanding as other companies that this proposal can be merged with Proposal 3.1-1 |
| Samsung | We suggest discussing this proposal with Proposal 3.1-1 together. |
| LG | We are also supportive of the proposal. We prefer to merge the proposal into proposal 3.1-1 and discuss all the issues together. |
| InterDigital | We are supportive of the proposal. However, similar to Ericsson and OPPO, we think that this proposal can be merged to Option 2 of Proposal 3.1-1. |

### Proposal 3.1-3 (H)

* Subject to UE’s capability, support a UE to measure the DL PRS resources from the same TRP with the same or different UE Rx TEGs, and report multiple RSTD measurements from the same pair of TRPs.
* FFS: details of the signalling, procedures, and UE capability

Comments

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| **Company** | **Comments** |
| ZTE | Support in principle. ‘report multiple RSTD measurements from the same pair of TRPs’ is already supported in the spec, so this description may not be needed. |
| OPPO | This proposal should be postponed untile some agreement is achieved for Proposal 3.1-1 or 3.1-2. The reasons are as below  1. If option 1 of Proposal 3.1-1 is agreed, LMF cannot know the association of measurement results for the same pair of TRP and the TEGs. How does Option 1 and Proposal 3.1-3 work together?  2. If option 2 of Proposal 3.1-1 or Proposal 3.1-2 is agreed, each measurement result will associated with a Rx TEG for the target TRP and UE can report multiple measurement results for the same target TRPs. In this sense, Proposal 3.1-3 can be supported without any additional agreement. Whether UE will use the same Rx TEG or different Rx TEGs for the same pair of TRPs, it depends on UE implementation and the location/environment of UE. |
| Fraunhofer | Support |
| CATT | Support. |
| vivo | Support |
| Ericsson | Support. This is very important since signaling TEG association in itself isn’t sufficient to fully mitigate timing errors and to reach Rel. 17 target requirements. This technique is needed (see simulation results below)!  Chart  Description automatically generated  Figure Utilization of antenna panel (or UE RX TEG) info is seen to give a very big improvement but still fails to fully mitigate the UE RX timing errors and to fulfill Rel. 17 positioning accuracy requirements in the InF-SH scenario. However, the combination of two techniques, 1) utilization of antenna panel (or UE RX TEG) info, and 2) sequentially performing one TOA estimate for each antenna panel towards the same TRP, result in complete mitigation of the UE RX timing errors and fulfillment of Rel. 17 positioning accuracy requirements. |
| Huawei, HiSilicon | Support. This can be easily achieved by enhancing the multiple measurements per TRP pair in Rel-16. |
| Qualcomm | We already have multiple RSTD reporting per pairs of TRPs, so the proposal needs to be clarified further.  Also, similar to what OPPO is saying, if the RxTEG is associated with the RSTD (which is our understanding also based on previous agreeemnt), a UE, up to implementation, if it has multiple RxTEGs, could report multiple RSTDs for the same set of TRPs. This will happen automatically by using the feature of multiple measurement reporting (which now supports up to 4 RSTDs). If we just add an RxTEG in each “additional measurement”, which I assume would be the case already based on previous agreement.  NR-DL-TDOA-AdditionalMeasurementElement-r16 ::= SEQUENCE {  nr-DL-PRS-ResourceID-r16 NR-DL-PRS-ResourceID-r16 OPTIONAL,  nr-DL-PRS-ResourceSetID-r16 NR-DL-PRS-ResourceSetID-r16 OPTIONAL,  nr-TimeStamp-r16 NR-TimeStamp-r16,  nr-RSTD-ResultDiff-r16 CHOICE {  k0-r16 INTEGER (0..8191),  k1-r16 INTEGER (0..4095),  k2-r16 INTEGER (0..2047),  k3-r16 INTEGER (0..1023),  k4-r16 INTEGER (0..511),  k5-r16 INTEGER (0..255),  ...  },  nr-TimingQuality-r16 NR-TimingQuality-r16,  nr-DL-PRS-RSRP-ResultDiff-r16 INTEGER (0..61) OPTIONAL,  nr-AdditionalPathList-r16 NR-AdditionalPathList-r16 OPTIONAL,  RxTEG-ID  ...  }  Therefore, a more specific/clear proposal would be:   * Subject to UE’s capability, support a UE to be able to report a separate RxTEGID for each of the RSTD measurements per pair of TRPs, including those in the *NR-DL-TDOA-AdditionalMeasurements.* |
| MTK | The wording seems a little vague to us. In our views, the significant measurement needs to contain the following two cases, otherwise the timing error can’t be mitigated.  1, A RSTD is measured by a RX TEG of UE between two resources of a TRP. This TRP could be reference TRP, or a neighbour TRP. This is to measure whether there is extra timing error during TX beam switching  2, A RSTD is measured by two RX TEGs of UE under same resource of a TRP. This TRP could be reference TRP, or a neighbour TRP. This is to measure the RX TEG difference  To FL, we want to make sure the above two cases are contained. Then we support |
| Apple | Questions for clarification: is it subject to multiple Rx TEGs at UE? Otherwise multiple RSTD reports is already specified. We also think better to postpone after we agree on 3.1-1 (and 3.1-2) |
| Nokia.NSB | Agree with QC that the FL proposal is not clear. The version from QC seems better to us. |
| CMCC | If I remembered correctly, in the last meeting, it was proposed that by supporting a UE to measure the RSTD from the same TRP pair using different UE Rx TEGs can help the LMF to estimate the timing error difference between different UE Rx TEGs, so that the Rx timing errors can be further compensated. However, in our view, this solution relies on the assumption that the propagation delay between the same TRP and different Rx TEGs are the same, which we believe cannot be guaranteed all the time and therefore the benefits would be limited. |
| Samsung | Maybe a silly question, how to exactly “measure” the RSTD with a given Rx TEG? Does it like tracking the first arrival path time and then plus the timing error value? |
| LG | Support. |
| InterDigital | Support |

### Proposal 3.1-4

* + For UE-based DL-TDOA, support a UE to receive the Tx-TEG information for each PRS resource in the unicast or broadcast assistance data.

Comments

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| **Company** | **Comments** |
| OPPO | OK |
| CATT | Support. |
| vivo | We think the previous agreement is reached on the condition that if TRP has multiple TEGs, the proposal also should be discussed in the condition. |
| Qualcomm | Support. Clearly fine to add that condition; it is understood. |
| Apple | Support (and suggest to change the text to “at least” for UE-based…) |
| Nokia/NSB | Unclear that we need to be so specific in “unicast or broadcast”. We are okay with UE receiving this information and RAN2 can decide how the UE gets that information. |
| Sony | Support. The details whether unicast or broadcast assistance data should be discussed in RAN2. |
| ZTE | Support. Suggest to remove ‘in the unicast or broadcast assistance data’. |
| LG | We have similar view with Nokia/NSB and Sony. |
| InterDigital | Support |

### Proposal 3.1-5

* + For DL TDOA, support the LMF to indicate which Rx TEG(s) to use for the reception of one or more DL-PRS resources.

Comments

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| **Company** | **Comments** |
| OPPO | Not support. How does LMF know which Rx TEG should be used for a given PRS resource? |
| CATT | Support. We think this proposal just try to let LMF to recommend the proper Rx TEGs to UE for the reception of DL-PRS, in order to facilitate the mitigation of the timing error. |
| Qualcomm | Not support |
| Apple | Support the intention, as long as indication is taken as suggestion to UE. |
| Nokia/NSB | We think there needs to be more clarification how this would work and what would be gained. TEGs by definition can vary over time so how is the network to know which Rx TEG is best for the UE to use for positioning measurements? |
| Sony | Do not support, we prefer it is up to the UE to decide. |
| ZTE | Do not support. DL-TDOA already has a real-time report configuration through LPPa, so there is no need to restrict UE’s behaviour. |
| LG | Not support. We think the decision on which RX TEG is used is up to UE. So, it is not necessary to discuss additional restrictions. |
| InterDigital | Support. In our view, LMF can recommend the UE to use the same of different Rx TEG(s) for two or more DL-PRS resources. If the UE uses the same Rx TEG for one RSTD measurement, Rx timing error can be canceled out. On the other hand, if the UE uses different Rx TEG(s), the LMF can know the timing error difference between two TEGs. |

### Proposal 3.1-6

* For UE-assisted DL-TDOA positioning, support
  + TRP to provide the LMF with the Tx timing errors per Tx TEG (Option 3)
  + TRP to provide the LMF with the Tx timing error differences between Tx TEGs (Option 8)
  + LMF to provide UE with the Tx timing errors per Tx TEG (Option 4)
  + LMF to provide UE with the Tx timing error differences between Tx TEGs (Option 9)

Comments

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| **Company** | **Comments** |
| OPPO | Not support  1. Option 3/8: If TRP knows the errors, why doesn’t TRP do a calibration?  2. Option 4/9: If LMF konow the time errors, why doesn’t LMF indicate this information to TRP for compensation? |
| CATT | Support.  In our point of view, if TRP compensate the Tx timing errors, it means TRP have to adjust the timing of transmission of DL-PRS, which may lead to some interference to other DL signals. |
| vivo | At least, we think option 3 and option 4 are hard to get and unreasonable. |
| Nokia/NSB | We don’t think Options 3 and 4 are technically feasible. We are open to discussing Option 8 and 9 further but it should be lower priority than other proposals in our view. |
| SONY | Support. Do we intend to down-select later? (e.g. Option 3 versus Option 8) |
| ZTE | Do not support as we suggested in the last meeting |
| LG | Not support. We need to consider the original intention of defining TEG. |
| InterDigital | Support. In our view, if the LMF and TRP have such information (i.e., timing error of each TEG and timing error differences between Tx TEGs), they should provide such information to the UE to improve the accuracy positioning methods. However, Option 4 and 9 are for UE-B positioning. Therefore, we propose to modify the proposal as follow:   * For UE-assisted DL-TDOA positioning, support   + TRP to provide the LMF with the Tx timing errors per Tx TEG (Option 3)   + TRP to provide the LMF with the Tx timing error differences between Tx TEGs (Option 8) * For UE-based DL-TDOA positioning, support   + LMF to provide UE with the Tx timing errors per Tx TEG (Option 4)   + LMF to provide UE with the Tx timing error differences between Tx TEGs (Option 9) |

## UE Tx and TRP Rx timing errors for UL TDOA

Background

The following conclusion was made in RAN1#104e and RAN1#104bis-e, related to the option(s) for mitigating UE Tx and TRP Rx timing errors for UL TDOA.

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| Conclusion (RAN1#104e):  Study the following option(s) for mitigating UE Tx and TRP Rx timing errors for UL TDOA:   * Option 1:   + Support a TRP to provide the association information of RTOA measurements with Rx TEGs to LMF when the TRP reports the RTOA measurements * Option 2:   + Support a UE to provide the association information of SRS resources for positioning with UE Tx TEG(s) to LMF for UL TDOA positioning. * Option 3:   + Support a UE to provide Tx timing errors per Tx TEG to LMF for UL TDOA positioning. * Option 4:   + Support a UE to provide Tx timing error differences between Tx TEGs to LMF for UL TDOA positioning. * FFS: the details of the ignaling, procedures, and UE capability * FFS: How the TEGs are determined by the UE or TRP (could be by implementation, i.e., no specification impact) * Note: Other options are not precluded. * Note: Depending on the discussion results, none/one/multiple of the above options may be adopted in Rel-17.   Agreement (RAN1#104bis-e):  Support the following for mitigating UE Tx timing errors and/or TRP Rx timing errors for UL TDOA   * Support a TRP to provide the association information of RTOA measurements with TRP Rx TEG(s) to the LMF when the TRP reports the RTOA measurements to the LMF if the TRP has multiple Rx TEGs * Support a UE to provide under capability the association information of UL SRS resources for positioning with Tx TEGs to the LMF if the UE has multiple Tx TEGs   + FFS: Whether to support a UE to provide the association information of UL SRS resources for MIMO with Tx TEGs to the LMF if the UE has multiple Tx TEGs   + FFS: Whether the association information is sent directly from UE to LMF, or is first provided to gNB and then forwarded to LMF; * FFS: the details of the Signaling, procedures, and UE capability |

Submitted Proposals and FL comments

* (Huawei [R1-2104277](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104277.doc)[1]) Proposal 1: Support UE to be requested to report TEG information for MIMO SRS.
  + Note 1: This is an optional UE feature.
  + Note 2: The request of TEG information can serve as the functionality of informing UE of MIMO SRS used for positioning.
  + Note 3: Associating MIMO SRS with TEG in Rel-17 does not affect/restrict UE implementation of MIMO SRS transmission, i.e., legacy UE implementation of MIMO SRS can be inherited

FL: Issues related to MIMO SRS were discussed in the previous meeting w/o a conclusion. Suggest further discussion (Proposal 3.2-2)

* (Huawei [R1-2104277](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104277.doc)[1]) Proposal 2: Support gNB to report the associated SRS resource ID and port ID of the RTOA measurement..
* FL: Issues related to MIMO SRS were discussed in the previous meeting w/o a conclusion. Suggest further discussion (Proposal 3.2-2)
* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 5: The UE can be requested to provide the association information of SRS resources for positioning with UE Tx TEG(s) to LMF.
  + Including positioning accuracy requirement information in Tx TEG request

FL: I assume the main bullet is already supported, but including the accuracy requirements is not discussed before. Suggest further discussion (3.2-3)

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 6: Support the UE to directly provide the association information of SRS resources for positioning with UE Tx TEG(s) to LMF via LPP message.
  + Note: The way the UE provides Tx TEG association information to the LMF should be consistent with the way the LMF requests UE Tx TEG association information

FL: It is related to one of the FFS in the previous agreement. Suggest further discussion (Proposal 3.2-1)

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 9: Support the gNB to provide information related to SRS resource(s) ID to the LMF in RTOA measurement result, to help the LMF obtain the relationship between the RTOA measurement result and the Tx TEGs of SRS resource(s).

FL: This seems already supported in Rel-16 NRPPa

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 10: In UL-TDOA method, to eliminate the positioning error caused by the UE Tx timing errors of more than one UE Tx TEGs, the RTOA measurement report for more than one UE Tx TEGs needs to be guaranteed if the gNB is able to measure SRS resoures associated different UE Tx TEGs.
  + FFS the gNB reporting rules to guarantee the RTOA measurement report for more than one UE Tx TEGs

FL: Discussed in previous meeting w/o conclusion. Suggest further discussion (Proposal 3.2-4)

* (CATT, [R1-2104520](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104520.doc)[3]) Proposal 13: For UL-TDOA positioning, the following two methods should also be supported to help LMF eliminate the influence of timing error of TRPs and UE:
* *Provide LMF with the Tx timing errors per Tx TEG.*

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| UL-TDOA | From | To | Signalling for mitigating UE Tx timing errors |
| Option 3 | UE | LMF | Tx timing errors per Tx TEG |

* *Provide LMF with the Tx timing error differences between Tx TEGs.*

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| UL-TDOA | From | To | Signalling for mitigating UE Tx timing errors |
| Option 4 | UE | LMF | Tx timing error differences between Tx TEGs |

FL: These options were discussed in the previous meeting w/o a conclusion. Suggest further discussion (Proposal 3.2-5)

* (ZTE, [R1-2104590](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104590.doc)[4]) Proposal 2: Whether Tx TEG is associated with SRS resource, SRS resource set or SRS port depends on different SRS usages and UE capability, e.g. UE antenna coherent capability, UE antenna switching capability, etc.

FL: Issues related to MIMO SRS were discussed in the previous meeting w/o a conclusion. Suggest further discussion (Proposal 3.2-2)

* (ZTE, [R1-2104590](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104590.doc)[4]) Proposal 3: Support to include UE Tx TEG information in location measurement report.

FL:It is related to one of the FFS in the previous agreement. Suggest further discussion (Proposal 3.2-1)

* (Qualcomm, [R1-2104671](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104671.doc)[6]) Proposal 4: Support TxTEG-to-SRS association reporting as part of the LPP signaling framework:
  + A UE should be able to report capability information related to Tx TEGs
  + A UE should be able to report association of Tx TEGs to SRS resources for positioning together with a timestamp (e.g. in a Provide Location Information message) to the LMF

FL:It is elated to one of the FFS in the previous agreement. Suggest further discussion (Proposal 3.2-1)

* (Qualcomm, [R1-2104671](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104671.doc)[6]) Proposal 5: Do not support Tx TEGs reporting for MIMO SRS.

FL: Issues related to MIMO SRS were discussed in the previous meeting w/o a conclusion. Suggest further discussion (Proposal 3.2-2)

* (OPPO, [R1-2104739](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104739.doc)[7]) Proposal 1: Rel-17 doesn’t support the association of TEG with MIMO SRS port(s).

FL: Issues related to MIMO SRS were discussed in the previous meeting w/o a conclusion. Suggest further discussion (Proposal 3.2-2)

* (OPPO, [R1-2104739](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104739.doc)[7]) Proposal 5: Rel-17 doesn’t support the association of TEGs with MIMO SRS resources.

FL: Issues related to MIMO SRS were discussed in the previous meeting w/o a conclusion. Suggest further discussion (Proposal 3.2-2)

* (OPPO, [R1-2104739](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104739.doc)[7]) Proposal 6: For the association information of TEGs and SRS resources for positioning, Rel-17 supports UE to report it to gNB and gNB to forward it to LMF via NRPPa.

FL:It is related to one of the FFS in the previous agreement. Suggest further discussion (Proposal 3.2-1)

* (InterDigital, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[8]) Proposal 6: Support a UE to provide the association information of UL SRS resources for MIMO with Tx TEGs to the LMF if the UE has multiple Tx TEGs

FL: Issues related to MIMO SRS were discussed in the previous meeting w/o a conclusion. Suggest further discussion (Proposal 3.2-2)

* (InterDigital, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[8]) Proposal 8: For UL TDOA, support the LMF to indicate which Tx TEG(s) to use for transmission in one or more UL PRS resources.

FL: Unclear how LMF knows which Tx TEG(s) the UE should use for the transmission of UL PRS resources. Suggest further discussion (Proposal 3.2-6)

* (Sony, [R1-2105168](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105168.doc)[11]) Proposal 2: In UL-TDOA positioning,
  + If a TRP is aware of its own Rx timing errors, support TRP to provide TRP Rx timing errors associated with the RTOA measurements to the LMF.
  + If a TRP is not aware of its own Rx timing errors, support TRP to provide the ID/index of TRP Rx TEGs associated with the RTOA measurements to the LMF if the TRP has multiple Rx TEGs.
  + If UE is aware of its own Tx timing errors, support UE to provide the UE Tx timing errors associated with the UL SRS resources to the LMF.
  + If UE is not aware of its own Tx timing errors, support UE to provide the ID/index of UE Tx TEGs associated with the UL SRS resources to the LMF if the TRP has multiple Rx TEGs.

FL: These options were discussed in the previous meeting w/o a conclusion. Suggest further discussion (Proposal 3.2-5)

* (Samsung, [R1-2105310](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105310.doc))[12]) Proposal 4: Support that the association information is sent directly from UE to LMF when the calculation of UL-TDOA is done at LMF. Otherwise it can be provided to the gNB first if the calculation is done at the gNB side.

FL: It is related to one of the FFS in the previous agreement. Suggest further discussion (Proposal 3.2-1)

* (DOCOMO, [R1-2105699](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105699.doc) [15]) Observation 1: Regarding mitigating UE Tx timing errors for UL-TDOA, the mitigation enhancements should be introduced for UL positioning using SRS resources for MIMO

FL: Issues related to MIMO SRS were discussed in the previous meeting w/o a conclusion. Suggest further discussion (Proposal 3.2-2)

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 4 The UE TX TEG association of UL SRS transmissions should be sent by the UE to the gNB and then forwarded to the LMF.

FL: It is related to one of the FFS in the previous agreement. Suggest further discussion (Proposal 3.2-1)

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 5 The UE can be configured to send TX TEG association reports for all SRS types.

FL: Issues related to MIMO SRS were discussed in the previous meeting w/o a conclusion. Suggest further discussion (Proposal 3.2-2)

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 6 The UE can be configured with a list of SRS resource sets for which UE TX TEG association reporting should be performed.

FL: The association of SRS resource sets and TX TEG should be determined by UE. It is unclear how and why the LMF/gNB to configure it Suggest further discussion (Proposal 3.2-6)

FL additional comments

In RAN1#104bis-e, there was an intensive discussion related to whether to support a UE to provide the association information of UL SRS resources for MIMO with Tx TEGs. In this meeting, it seems there are still quite different views on this issue. A number of companies (e.g., [1][4][5][8][19]) are supportive for UE to provide the association information of UL SRS resources for MIMO with Tx TEGs. However, some other companies propose not to support it (e.g., [6][7][8]). Suggest having a further discussion in this meeting.

For the remaining issue “Whether the association information is sent directly from UE to LMF, or is first provided to gNB and then forwarded to LMF”, it seems the majority of companies support UE to provide the association information directly to LMF (e.g., [2][4][6][11][12]), but there are some companies propose the association information is first provided to gNB and then forwarded to LMF (e.g., [7][19]).

In [3][11], it was proposed to support UE to provides LMF with the Tx timing errors per Tx TEG; In [3], it was proposed to support UE to provides LMF with the Tx timing error differences between Tx TEGs; and in [11], it was proposed TRP to provide TRP Rx timing errors associated with the RTOA measurements to the LMF.

### Proposal 3.2-1 (H)

* For mitigating UE Tx timing errors and/or TRP Rx timing errors for UL TDOA, support one of the following options:
  + Option 1:
    - Subject to UE’s capability, support a UE to provide the association information of UL SRS resources for positioning with Tx TEGs *directly* to the LMF if the UE has multiple Tx TEGs.
    - Support LMF to forward the association information provided by the UE to the serving and neighboring gNBs
  + Option 2:
    - Subject to UE’s capability, a UE should support providing the association information of UL SRS resources for positioning with Tx TEGs to the *serving* gNB if the UE has multiple Tx TEGs.
    - Support the *serving* gNB to forward the association information provided by the UE to the LMF
    - Support LMF to forward the association information from the *serving* gNB for the UE to the neighboring gNBs
* UE should be able to report capability information related to Tx TEGs to LMF via LPP signaling

Comments

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| **Company** | **Comments** |
| ZTE | Support option 2 |
| OPPO | We prefer Option 2 since the SRS configuration/triggering are all controlled by gNB |
| Fraunhofer | The TEG information is needed at the LMF for UL-TDOA position estimation. For Option1: the motivation for supporting LMF to forward the association information is unclear, the LMF can provide the gNB with SRS configuration information.  On Option2, the third subbullet why is should TEG information be helpful to determine an RTOA? |
| CATT | Support option 1. Option 1 is sample and introduce less signalling overhead. About the SRS configuration, maybe it can be informed to LMF by gNB. |
| vivo | Support option1.  Firstly, in the current spec, direct UL capability interaction between UE and LMF already exists, and Tx TEG request/report can also use a similar way. Secondly, different with SRS configuration, the UE Tx TEG information is determined by the UE and there is no use for the serving gNB to obtain this information before other neighboring gNB. |
| Ericsson | We support Option 2. The serving gNB is controlling the SRS radio resources and should have access to all information that can be useful in controlling interference. In a single gNB multi TRP scenario (e.g. in indoor IIOT), this reduces the latency and amount of NRPPa signalling. We also note, that if the information is sent ‘directly’ to the LMF over LPP it’s of course still passing the serving gNB. The only difference is that the gNB doesn’t have access to the LPP message content. |
| Huawei, HiSilicon | We do not see the need to expose TEG info to the non-serving gNB, and from gNB measurement perspective, the UL RTOA measurement can be associated with the SRS resource set/SRS resource/SRS port, and LMF may further link the results with TEG reported from the UE.  In addition, we would like to emphasize that in order the complete the loop of associating UE Rx TEG with RTOA measurement, there should be a crucial procedure to allow the measuring gNB to provide the RTOA measurement with   * Option 1: SRS resource set ID, and/or SRS resource ID, and/or SRS port ID (if supported)   + LMF will link the RTOA measurement with the UE Tx TEG information based on the IDs * Option 2: UE Tx TEG ID   + Note: This Option would require LMF to provide the UE Tx TEG ID to the measuring gNB along with the SRS configuration   Our following proposal is trying to resolve this issue, not necessarily associated with MIMO SRS used for TEG reporting, and it should also be applicable for positioning SRS, in which case the port ID reporting is not necessary.   * Proposal 2: Support gNB to report the associated SRS resource ID and port ID of the RTOA measurement. |
| Qualcomm | Option 1. Support a single solution for both UTDOA and RTT. LPP is the right protocol to do so. |
| Apple | Support Option 1, given that positioning estimation is anyway done by LMF |
| Nokia/NSB | We support Option 2 without the third subbullet. We have the same understanding as Huawei that this information is not useful at neighboring gNB. |
| SONY | Support Option 1 |
| CMCC | Support Option 1, and for the 2nd bullet, we think that there is no need for the LMF to forward this association information to serving and neighboring gNBs. The gNBs will report the RTOA measurements associated with UL SRS resources (sets) to the LMF, which can have the complete information about the relationship with measurements/resources (sets) and TEGs. |
| Samsung | Option 1 is preferred.  Indeed the signalling will be transferred from serving gnb anyway, the difference is the serving gnb is allowed to decoded it or not. If the calculation is done at LMF, it seems not necessary, but if it is done at gNB side, it could be helpful. Considering mostly there could be multiple RSTD measurement to form the final results, we see the option1 may be more likely to happen. |
| LG | Support Option 1. |
| InterDigital | Support Option 1 since it is simpler and less signalling overhead then Option 2. |

### Proposal 3.2-2 (H)

* Subject to UE’s capability, support a UE to provide the association information of Tx TEGs with UL SRS resources for MIMO and port IDs to the LMF for UL-TDOA if the UE has multiple Tx TEGs.

Comments

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| **Company** | **Comments** |
| ZTE | Considering the association between Tx TEG and SRS port/SRS resource/SRS resource set, we suggest to modify the main bullet and add a FFS:   * Subject to UE’s capability, support a UE to provide the association information of Tx TEGs with UL SRS resources or SRS resource sets for MIMO and port IDs to the LMF for UL-TDOA if the UE has multiple Tx TEGs. * FFS: Whether Tx TEG is associated with SRS resource, SRS resource set or SRS port. |
| OPPO | Not support. In Rel-16, it is transparent to UE whether MIMO SRS is used for positioning purpose or not. This proposal will break Rel-16 principle of transparency. |
| Fraunhofer | Ok with the proposal with following changes:   * Subject to UE’s capability, support a UE to provide the association information of the Tx TEGs transmited over multiple ports with UL SRS resources for MIMO ~~and port IDs~~ to the LMF for UL-TDOA ~~if the UE has multiple Tx TEGs~~. |
| vivo | According to Huawei’s Tdoc, the relationship between Tx TEG and SRS seems different for different usages. For example, the beam usage is associated with the SRS set, and the non-codebook usage is associated with the SRS resource. But it doesn’t reflect in this proposal.  We propose to first discuss whether extending Tx TEG to SRS for MIMO . If agreed, the association information of Tx TEGs with which SRS can be discussed. |
| Ericsson | Support the proposal. UL SRS resources are scarce. The possibility of re-using the same UL SRS resources for multiple purposes is very important. |
| Huawei, HiSilicon | Support. We would like to emphysize the Note 3 in our paper to address OPPO’s concern.   * + Note 3: Associating MIMO SRS with TEG in Rel-17 does not affect/restrict UE implementation of MIMO SRS transmission, i.e., legacy UE implementation of MIMO SRS can be inherited |
| Qualcomm | Not support. SRS for MIMO is not intended for Positioning. Reusing it for UL-TDOA is supposed to be a transparent/backward-compatible feature. Enhancements should be targeted for SRS for Positioning. |
| Apple | Do not support. We share similar view as OPPO and Qualcomm. Using MIMO SRS for positioning is not transparent to UE in currents specification. Besides, PosSRS is designed and specified for this purpose. No need to specify TEG for MIMO SRS where the use-case, and pros/cons are not well studied. |
| SONY | Similar view as QC. As of now, SRS for MIMO is not designed for positioning. |
| ZTE2 | MIMO SRS can already be used in the current spec in UL-TDOA and UL-AoA, if Tx TEG can be associated with pos SRS, it is reasonable to associate Tx TEG with MIMO SRS for consistency. Maybe this requires another UE capability. |
| Samsung | Not support. As vivo suggests, we can first discuss whether to enhance MIMO SRS in this release. |
| InterDigital | Support the proposal. |

### Proposal 3.2-3

* The UE can be requested to provide the association information of SRS resources for positioning with UE Tx TEG(s) to LMF, including positioning accuracy requirement information in the Tx TEG request.

Comments

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| **Company** | **Comments** |
| OPPO | What does “positioning accuracy requirement information in the Tx TEG request” refer to? Is it related to the current discussion? |
| vivo | Support |
| Qualcomm | Clearly there is going to be a request to the UE, otherwise why would the UE start reporting it? Is this proposal about the “positioning accuracy requirement”? |
| Nokia/NSB | What does this proposal bring over proposal 3.2-1? |
| SONY | FFS. The purpose of positioning accuracy requirement information is unclear. |
| ZTE | Do not support. Supporting TEG is a UE capability. If UE has the capability, UE can always report Tx TEG information rather than being requested. |
| LG | Before discuss it, could you gie us the motivation of the proposal. |
| InterDigital | Support |

### Proposal 3.2-4

* For UL-TDOA positioning, support a gNB to report RTOA measurements associated with different UE Tx TEGs from a UE.

Comments

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| **Company** | **Comments** |
| ZTE | Support FL’s proposal |
| OPPO | Is it a counterpart of Proposal 3.1-3 for UL-TDOA? If so, “different UE Tx TEGs from a UE” should be “different Rx TEGs”. |
| vivo | Support |
| Nokia/NSB | Unclear what this means. The gNB doesn’t have or need UE Tx TEG information for RTOA measurements in our view. |
| SONY | We do not suppot because it is still unclear how does gNB know the association information between the RTOA measurement and UE Tx TEGs. |
| LG | Support. |

### Proposal 3.2-5

* For UL-TDOA positioning, support
  + UE provides LMF with the Tx timing errors per Tx TEG
  + UE provides LMF with the Tx timing error differences between Tx TEGs
  + TRP to provide TRP Rx timing errors associated with the RTOA measurements to the LMF

Comments

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| **Company** | **Comments** |
| OPPO | Not support. Similar comment as Proposal 3.1-6 |
| CATT | In our point of view, if UE compensate the Tx timing errors, it means UE have to adjust the timing of transmission of SRS-Pos, which may lead to some interference to other UL signals. |
| Nokia/NSB | Same comments as in proposal 3.1-6. |
| SONY | Support sub-bullet 1. |
| ZTE | Do not support as we suggested in the last meeting |
| LG | Not support. We have the same view in proposal 3.1-6. |
| InterDigital | Support |

### Proposal 3.2-6

* For UL TDOA, support the LMF to configure which Tx TEG(s) to use for transmission in one or more UL PRS resources.

Comments

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| **Company** | **Comments** |
| OPPO | Not support. How does LMF which Tx TEG is suitable for the a given SRS resources for positioning? The Tx beam is controlled by gNB |
| CATT | Support. We think this proposal just try to let LMF to recommend the proper Tx TEGs to UE for the transmission of SRS-Pos, in order to facilitate the mitigation of the timing error. |
| SONY | Do not support |
| ZTE | Support FL’s proposal. The reason is, if Tx TEG can be indicated to UE, UE will need no Tx TEG report, which requires much less spec impact. We are not sure the Tx TEG should be configured by LMF or serving gNB, so maybe we can change the proposal like this:   * For UL TDOA, support UE to receive the configuration that which Tx TEG(s) to use for transmission in one or more UL ~~PRS~~SRS resources. * FFS: whether the configuration comes from LMF or serving gNB. |
| LG | It seems that some clarifications are needed. Actually, we think that the recommendation from LMF is okay for gNB. But, the subject of decision must be a gNB. |
| InterDigital | Support for the similar reason as Proposal 3.1-5. |

## UE/gNB Rx/Tx timing errors in DL+UL positioning

Background

The following agreements were made in RAN1#104e and RAN1#104bis-e, related to the option(s) for mitigating UE Rx/Tx timing errors in DL+UL positioning. In this meeting, there is a need to decide which alternative (option) should be supported.

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| Agreement (RAN1#104bis-e)  For mitigating UE/TRP Tx/Rx timing errors for DL+UL positioning, support one of the following alternatives:   * Alt.1: Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a pair of {Rx TEG, Tx TEG} to LMF, where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit the UL Positioning SRS; * Alt.2: Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a UE RxTx TEG to LMF according to the one of the 2 following options:   + Option 1: the UE RxTx TEG is associated with one or more {DL PRS resource, UL Positioning SRS resource} pairs     - FFS: whether UE provides the association information of DL PRS resources to UE Rx TEG to LMF for UE RxTx measurements specifically   + Option 2: the UE RxTx TEG is associated with one or more {Rx TEG, Tx TEG} pairs where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit the UL Positioning SRS. * For both alterntives, the UE may provide the association information of SRS resources for positioning to UE Tx TEG to LMF   + FFS: Whether the association information is sent directly from UE to LMF, or is first provided to gNB and then forwarded to LMF * FFS: the details of the signalling, procedures, and UE capability   Agreement: (RAN1#104bis-e)   * For mitigating UE/TRP Tx/Rx timing errors for DL+UL positioning, support one of the following alternatives:   + Alt.1: Support a gNB to provide the association information of a gNB Rx-Tx time difference measurement with a pair of {Rx TEG, Tx TEG} to LMF   + Alt. 2: Support a gNB to provide the association information of a gNB Rx-Tx time difference measurement with a TRP RxTx TEG to LMF, if the TRP has multiple RxTx TEGs, according to the one of the 2 following options:     - Option 1: the TRP RxTx TEG is associated with one or more {DL PRS resource, UL Positioning SRS resource} pairs       * FFS: whether gNB provides the association information of UL Positioning SRS resources to TRP Rx TEG to LMF, if the TRP has multiple Rx TEGs, for gNB RxTx measurements specifically     - Option 2: the TRP RxTx TEG is associated with one or more {Rx TEG, Tx TEG} pairs where the Rx TEG is used to receive the UL Positioning SRS and the Tx TEG is used to transmit the DL PRS.   + For both alternatives, the gNB may provide the association information of DL PRS resources to TRP Tx TEG to LMF if the TRP has multiple Tx TEGs. * FFS: the details of the signalling, procedures |

Submitted Proposals and FL comments

* (Huawei [R1-2104277](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104277.doc)[1]) Proposal 3: Support
  + A UE to provide the association information of a UE Rx-Tx time difference measurement with a UE RxTx TEG to LMF.
  + A gNB to provide the association information of a gNB Rx-Tx time difference measurement with a TRP RxTx TEG to LMF, if the TRP has multiple RxTx TEGs.

FL:Related to the remaining issues in previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2, 3.3-3)

* (Huawei [R1-2104277](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104277.doc)[1]) Proposal 4: Support reporting association of UE Rx – Tx time difference, UE RxTx TEG and UE Tx TEG in the multi-RTT measurement reporting.
  + Note: this implies that a RxTx TEG is associated with multiple pairs of Rx TEG and Tx TEG, where the Rx TEG is not explicitly reported

FL:Related to the remaining issues in previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2, 3.3-3)

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 11: Support UE to provide the association information of DL PRS resources to UE Rx TEG to LMF for UE RxTx measurements under capability.

FL:Related to the remaining issues in previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2, 3.3-3)

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 12: Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a UE RxTx TEG under capability.
  + The UE RxTx TEG is associated with one or more {DL PRS resource, UL Positioning SRS resource} pairs

FL:Related to the remaining issues in previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 13: The SRS resource(s) in the most recent SRS instance in advance of the Rx-Tx time difference measurement can be used to derive RxTx TEG or Tx TEG in { Rx TEG, Tx TEG } pairs for Rx-Tx time difference measurements.

FL: Suggest further discussion (Proposals 3.3-4)

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 14: Support UE to provide Tx TEG information of SRS resources for positioning along with Rx-Tx time difference measurements via ‘NR-Multi-RTT-SignalMeasurementInformation’.

FL: Which IE to use can be discussed in RAN2.

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 15:
  + Support gNB to provide the association information of a gNB Rx-Tx time difference measurement with a TRP RxTx TEG to LMF, if the TRP has multiple RxTx TEGs.
  + Support gNB to provide the association information of UL Positioning SRS resources to TRP Rx TEG to LMF, if the TRP has multiple Rx TEGs, for gNB RxTx measurements.

FL: Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-3)

* (CATT, [R1-2104520](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104520.doc)[3]) Proposal 14: For DL+UL positioning methods, the following Alt.1 should be supported to help LMF eliminate the influence of timing error of UE:
  + Alt.1: Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a pair of {Rx TEG, Tx TEG} to LMF, where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit the UL Positioning SRS.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (CATT, [R1-2104520](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104520.doc)[3]) Proposal 15: For DL+UL positioning methods, the following Alt.1 should be supported to help LMF eliminate the influence of timing error of TRPs:
  + Alt.1: Support a gNB to provide the association information of a gNB Rx-Tx time difference measurement with a pair of {Rx TEG, Tx TEG} to LMF.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-3)

* (ZTE, [R1-2104590](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104590.doc)[4]) Proposal 1: For DL+UL positioning, support a UE to provide the association information of a UE Rx-Tx time difference measurement with a pair of {Rx TEG, Tx TEG} to LMF.
  + Support an additional UE capability to indicate which {Rx TEG, Tx TEG} pairs are in a same RxTx TEG.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (CMCC, [R1-2104611](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104611.doc)[5]) Proposal 4: For mitigating UE/TRP Tx/Rx timing errors for DL+UL positioning, support a UE to provide the association information of a UE Rx-Tx time difference measurement with a UE RxTx TEG to LMF:
  + The UE RxTx TEG is associated with one or more {Rx TEG, Tx TEG} pairs where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit the UL Positioning SRS.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (CMCC, [R1-2104611](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104611.doc)[5]) Proposal 5: For mitigating UE/TRP Tx/Rx timing errors for DL+UL positioning, support a gNB to provide the association information of a gNB Rx-Tx time difference measurement with a TRP RxTx TEG to LMF, if the TRP has multiple RxTx TEG:
  + The TRP RxTx TEG is associated with one or more {Rx TEG, Tx TEG} pairs where the Rx TEG is used to receive the UL Positioning SRS and the Tx TEG is used to transmit the DL PRS.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-3)

* (Qualcomm, [R1-2104671](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104671.doc)[6]) Proposal 6: For mitigating UE/TRP Tx/Rx timing errors for DL+UL positioning, support Alt. 2
* A UE should be able to provide an association of each UE RxTx measurement to an RxTx TEG ID.
* Irrespective of Opt. 1 or Opt. 2, the association of RxTx-TEGs to {PRS ID, SRS ID} (Opt. 1), OR to {RxTEG ID, TxTEG ID} (Opt.2) should be optionally provided in addition to the RxTx-TEG IDs.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2, 3.3-3)

* (OPPO, [R1-2104739](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104739.doc)[7]) Proposal 7: For mitigating UE/TRP Tx/Rx timing errors for DL+UL positioning, Rel-17 NR support Alt.1, i.e.,
  + UE provides the association information of a UE Rx-Tx time difference measurement with a pair of {Rx TEG, Tx TEG} to LMF, where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit the UL Positioning SRS

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (OPPO, [R1-2104739](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104739.doc)[7]) Proposal 8: For mitigating UE/TRP Tx/Rx timing errors for DL+UL positioning, Rel-17 NR support Alt.1, i.e.,
  + gNB to provide the association information of a gNB Rx-Tx time difference measurement with a pair of {Rx TEG, Tx TEG} to LMF

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-3)

* (InterDigital, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[8]) Proposal 9: For TEG for DL+UL positioning, support Option 2 of Alt. 2 for both UE and gNB cases.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2, 3.3-3)

* (Intel, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[9]) Proposal 1: For mitigating UE/gNB RX/TX timing errors for the DL+UL positioning, support the following:
  + Support a UE to provide the association information of a pair of {TX TEG ID, RX TEG ID} with a UE Rx-Tx time difference measurement to LMF, where TX TEG ID is used to transmit the UL Positioning SRS and RX TEG ID is used to receive the DL PRS
  + The UE may provide the association information of the UE TX TEG ID with the UL Positioning SRS resources to LMF, if the UE has multiple TX TEGs
    - Note: if association information of the TX TEG ID with the UL Positioning SRS resources is provided, then a UE may report the RX TEG ID only associated with the UE Rx-Tx time difference measurement

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (Intel, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[9]) Proposal 2: For mitigating UE/gNB RX/TX timing errors for the DL+UL positioning, support the following:
  + Support a gNB to provide the association information of a pair of {TX TEG ID, RX TEG ID} with a gNB Rx-Tx time difference measurement to LMF, where TX TEG ID is used to transmit the DL PRS and RX TEG ID is used to receive the UL Positioning SRS
  + The gNB may provide the association information of the TRP TX TEG ID with the DL PRS resources to LMF, if the TRP has multiple TX TEGs
    - Note: if association information of the TX TEG ID with the DL PRS resources is provided, then a gNB may report the RX TEG ID only associated with the gNB Rx-Tx time difference measurement

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-3)

* (Apple, [R1-2105105](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105105.doc)[10]) Proposal 5: For mitigating UE/TRP Tx/Rx timing errors for DL+UL positioning, “subject to UE capability” support the following
  + the UE RxTx TEG is associated with the cumulative TEG for DL PRS resource Rx and UL Positioning SRS Tx
  + the association information is sent from UE to LMF on LPP message
  + UE is not expected to additionally provide the association information of DL PRS resources to UE Rx TEG for m-RTT technique

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (Samsung, [R1-2105310](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105310.doc))[12]) Proposal 5: For Multi-RTT, UE provides the association information of a UE Rx-Tx time difference measurement with a UE RxTx TEG , which is associated with one or more DL PRS resource and UL Positioning SRS resource pairs.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (Nokia, [R1-2105512](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105512.doc)[14]) Proposal 5: Support Alt. 2, Option 1 in the prior agreement on UE Rx-Tx time difference measurements.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (Nokia, [R1-2105512](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105512.doc)[14]) Propsoal 6: Don’t support UE providing association of PRS resources and Rx TEG to LMF for UE Rx-Tx measurements.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (Nokia, [R1-2105512](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105512.doc)[14]) Propsoal 7: Support Alt. 2, Option 1 in the prior agreement on gNB Rx-Tx time difference measurements.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-3)

* (Nokia, [R1-2105512](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105512.doc)[14]) Propsoal 8: Don’t support TRP reporting the association information of SRS resource to TRP Rx TEG for gNB Rx-Tx measurements.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-3)

* (MTK, [R1-2105759](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105759.doc)[16]) Proposal 2-1: Support option 2 of Alt. 2, which is
  + Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a UE RxTx TEG to LMF according to the one of the 2 following options:
    - Option 2: the UE RxTx TEG is associated with one or more {Rx TEG, Tx TEG} pairs where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit the UL Positioning SRS.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (MTK, [R1-2105759](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105759.doc)[16]) Proposal 3-6: Support TRPs to report RX+TX group delay measurement to solve the inter-TRP transmission and receiving timing difference mathematically at the location server

FL:Discussed in previous meeting w/o conclusion. Suggest further discussion (Proposals 3.3-5)

* (MTK, [R1-2105759](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105759.doc)[16]) Proposal 3-7: Support UE to report RX+TX group delay measurement for each pair of {RX TEG, TX TEG} to solve transmission timing difference between TX TEGs and receiving timing difference between RX TEGs mathematically at the location server.

FL: Suggest further discussion (Proposals 3.3-5)

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 10 Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a pair of {Rx TEG, Tx TEG} to LMF, where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit the UL Positioning SRS (Alt. 1 in the agreement for mitigating UE/TRP Tx/Rx timing errors for DL+UL positioning, at RAN1#104bis\_e)

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 11 Support a UE RX TEG indication and an optional UE TX TEG indication in the UE RX-TX time difference measurement report. If the UE TX TEG indication is not present in the UE RX-TX time difference measurement report, the UE TX TEG is given through a one-to one relation by the UE RX TEG indication.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 12 Support a coupling between the UE RX-TX time difference measurement and an UL SRS transmission as given by an SRS ID and SRS occasion indication in the UE RX-TX time difference measurement report.

FL:Related to the remaining issues in the previous agreement. Suggest further discussion (Proposals 3.3-1, 3.3-2)

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 13 Introduce the possibility to configure the UE to perform multi UE-RX-TEG - UE RX-TX time difference measurements, i.e. one UE RX-TX time difference measurement for each UE RX TEG and TRP.

FL: Suggest further discussion (Proposals 3.3-6)

FL additional comments

Based on the feedback, it seems there are diversed opinions on the alternatives (options) from the interested companies [1-19], which can be summarized in the following. In my view, all these alternatives (options) should work as discussed in [21]. In this meeting, we may need to decide which of them should be supported.

**For mitigating UE Tx/Rx timing errors for DL+UL positioning:**

* Alt.1: Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a pair of {Rx TEG, Tx TEG} to LMF, where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit the UL Positioning SRS;
  + **Supported by:** *CATT, ZTE, OPPO, Intel, Ericsson*
* Alt.2: Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a UE RxTx TEG to LMF according to the one of the 2 following options:
  + Option 1: the UE RxTx TEG is associated with one or more {DL PRS resource, UL Positioning SRS resource} pairs
    - **Supported by:** *vivo, Qualcomm, Apple, Samsung, Nokia*
    - FFS: whether UE provides the association information of DL PRS resources to UE Rx TEG to LMF for UE RxTx measurements specifically
      * **Supported by:** *vivo*
      * **Not Supported by:** *Apple, Nokia*

Option 2: the UE RxTx TEG is associated with one or more {Rx TEG, Tx TEG} pairs where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit the UL Positioning SRS.

* + - **Supported by:** *Huawei, CMCC, Qualcomm, InterDigital, MTK*

**For mitigating TRP Tx/Rx timing errors for DL+UL positioning:**

* Alt.1: Support a gNB to provide the association information of a gNB Rx-Tx time difference measurement with a pair of {Rx TEG, Tx TEG} to LMF
  + - **Supported by:** *CATT, OPPO, Intel, Ericsson*
* Alt. 2: Support a gNB to provide the association information of a gNB Rx-Tx time difference measurement with a TRP RxTx TEG to LMF, if the TRP has multiple RxTx TEGs, according to the one of the 2 following options:
  + Option 1: the TRP RxTx TEG is associated with one or more {DL PRS resource, UL Positioning SRS resource} pairs
    - **Supported by:** *vivo, Qualcomm, Nokia*
    - FFS: whether gNB provides the association information of UL Positioning SRS resources to TRP Rx TEG to LMF, if the TRP has multiple Rx TEGs, for gNB RxTx measurements specifically
      * **Supported by:** *vivo*
      * **Not supported by:** *Nokia*
  + Option 2: the TRP RxTx TEG is associated with one or more {Rx TEG, Tx TEG} pairs where the Rx TEG is used to receive the UL Positioning SRS and the Tx TEG is used to transmit the DL PRS.
    - **Supported by:** *Huawei, CMCC, Qualcomm, InterDigital*

In this meeting, it seems we will need to a further discussion before making the decision on which one to support. To make it easier to collect the opinions from the companies and online discussion, Proposal 3.3-1 lists the Alt1, Alt1 (OP1), and Alt.2 (OP2) as three separate options in parallel.

### Proposal 3.3-1 (H)

* For mitigating UE Tx/Rx timing errors for DL+UL positioning, adopt one of the following options:
  + Option 1:
    - Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a pair of UE {Rx TEG, Tx TEG} to LMF, where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit the UL Positioning SRS;
  + Option 2:
    - Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a UE RxTx TEG to LMF. The UE RxTx TEG is associated with one or more {DL PRS resource, UL Positioning SRS resource} pairs
      * FFS: whether UE provides the association information of DL PRS resources to UE Rx TEG to LMF for UE RxTx measurements specifically
  + Option 3:
    - Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a UE RxTx TEG to LMF. The UE RxTx TEG is associated with one or more UE {Rx TEG, Tx TEG} pairs where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit the UL Positioning SRS.
* FFS: the details of the signalling, procedures, and UE capability

Comments

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| --- | --- |
| **Company** | **Comments** |
| ZTE | Support option 1. Whether 2 pairs of {Rx TEG, Tx TEG} can be assumed in a same RxTx TEG requires UE capability. There are two cases:   1. If UE can not calibrate the round trip delay, UE doesn’t know how to group x {Rx TEG, Tx TEG}pairs into y RxTx TEGs, so option 2 and option 3 can not work; 2. If UE has the calibration capability, UE can group x {Rx TEG, Tx TEG} pairs into y RxTx TEGs in advance, and report this information as UE capability. Then option 1 can still be adopted, LMF will know how to combine the measurement results according to the previous UE capability report. |
| OPPO | Ok to further discuss it. Option 1 is preferred. |
| CATT | Support option1. In our point of view, it will make the signalling for mitigating UE Rx/Tx timing errors more complicated and increase the overhead, if RxTx TEGs are introduced for DL+UL positioning methods. |
| vivo | Option 3 and with a small modification.  We support UE to provide the association information of DL PRS resources to UE Rx TEG to LMF for UE RxTx measurements under capability. Considering UE providing Rx TEG information in option2 is still listed as FFS, so option3 is preferred.  But UE Rx-Tx time difference measurement is DL measurement independent of actual SRS transmission. So we propose the Tx TEG is used to transmit in the timing of uplink subframe #j that is closest in time to the subframe #i received from the TP. Otherwise, if the current definition of Tx TEG is used, which SRS is selected also is a problem. And LMF also needs to replace the selected SRS for different receiving SRS in gNB Rx-Tx time difference.  Note: from the definition of Rx-Tx time difference, the reference point for TUE-TX measurement shall be the Tx antenna/antenna connector of the UE. Therefore, the Tx TEG is associated with Tx antenna/antenna connector for TUE-TX measurement.  So some modifications as follows   * + Option 3:     - Support a UE to provide the association information of a UE Rx-Tx time difference measurement with a UE RxTx TEG to LMF. The UE RxTx TEG is associated with one or more UE {Rx TEG, Tx TEG} pairs where the Rx TEG is used to receive the DL PRS and the Tx TEG is used to transmit ~~the UL Positioning SRS~~ in the timing of uplink subframe #j that is closest in time to the subframe #i received from the TP. |
| Ericsson | We support Option 1.  Having said that, we think it’s hard to agree on something here without seeing the whole concept. We note that a given TRP doesn’t listen to all SRSs transmitted by the UE. It’s therefore necessary to specify how the UE selects the SRS used for TX timing for a given UE RX-TX time difference measurement. This could be based either on  a) An explicit coupling of each DL PRS to an UL SRS signalled in assistance data  b) The spatial relation of the UL SRS towards a DL PRS or towards the SSB of the TRP from which the DL PRS is sent.  Regarding RxTx TEG we have understood from the proponents that UE self calibration could make RX+TX timing error differences small so that a UE Rx-Tx measurement using antenna panel 1 for both RX and TX could be in the same RxTx timing error group as a UE Rx-Tx measurement using antenna panel 2 for both RX and TX. If this is so, to our understandiung we don’t need TEGs at all. All UE Rx-Tx time difference measurements will be in the same RxTx TEG. It would be good if the proponents could explain this point. |
| Qualcomm | Option 2 or 3. Option 1 is NOT enough for some scenarios. To E//: it is not true that a UE will ALWAYS have panels calibrated. Maybe it depends on the time distance of the measurements, their bands, etc. So, a UE, at a first instance may be able to quarantee that 2 panels have similar errors, and in another instance may not be able to quarantee that.  **Can the proponents of Option 1 please tell me how will the UE report that the following 2 Rx-Tx measurements have the same RxTx timing error?**     * The UE cannot assign the 2 measurements the same TxTEG because the Tx Timing changed * The UE cannot assign them 2 measuremens the same RxTEG because the Rx Timing drifted.   **So, how will the LMF know that the RxTx Errors are similar between those measurements if the RxTEG-IDs and TxTEG-IDs are different?**  We don’t see any signaling complexity. It can just be an additional RxTxTEG-ID in the RTT report:  NR-Multi-RTT-MeasElement-r16 ::= SEQUENCE {  dl-PRS-ID-r16 INTEGER (0..255),  nr-PhysCellID-r16 NR-PhysCellID-r16 OPTIONAL,  nr-CellGlobalID-r16 NCGI-r15 OPTIONAL,  nr-ARFCN-r16 ARFCN-ValueNR-r15 OPTIONAL,  nr-DL-PRS-ResourceID-r16 NR-DL-PRS-ResourceID-r16 OPTIONAL,  nr-DL-PRS-ResourceSetID-r16 NR-DL-PRS-ResourceSetID-r16 OPTIONAL,  nr-UE-RxTxTimeDiff-r16 CHOICE {  k0-r16 INTEGER (0..1970049),  k1-r16 INTEGER (0..985025),  k2-r16 INTEGER (0..492513),  k3-r16 INTEGER (0..246257),  k4-r16 INTEGER (0..123129),  k5-r16 INTEGER (0..61565),  ...  },  RxTxTEGID INTEGER (0..X) OPTIONAL,  ...  } |
| Apple | Support Option 2 and OK with Option 3 as well. |
| Nokia/NSB | We support option 2. |
| SONY | We prefer option 1 |
| Huawei, HiSilicon | Although we support Option 3 in our contribution, we felt that both Option 1 and Option 2/3 can be supported subject to UE/network capability. For example, we can have the following ASN.1 structure.  NR-Multi-RTT-MeasElement-r16 ::= SEQUENCE {  dl-PRS-ID-r16 INTEGER (0..255),  nr-PhysCellID-r16 NR-PhysCellID-r16 OPTIONAL,  nr-CellGlobalID-r16 NCGI-r15 OPTIONAL,  nr-ARFCN-r16 ARFCN-ValueNR-r15 OPTIONAL,  nr-DL-PRS-ResourceID-r16 NR-DL-PRS-ResourceID-r16 OPTIONAL,  nr-DL-PRS-ResourceSetID-r16 NR-DL-PRS-ResourceSetID-r16 OPTIONAL,  nr-UE-RxTxTimeDiff-r16 CHOICE {  k0-r16 INTEGER (0..1970049),  k1-r16 INTEGER (0..985025),  k2-r16 INTEGER (0..492513),  k3-r16 INTEGER (0..246257),  k4-r16 INTEGER (0..123129),  k5-r16 INTEGER (0..61565),  ...  },  ...  [[  nrTEG-r17 CHOICE {  RxTEGID-r17 INTEGER (0..X1-1),  RxTxTEGID-r17 INTEGER (0..X2-1)  } OPTIONAL  ]]  }  BTW, we still think that TxTEG info should anyway be needed. |
| CMCC | We support Option 3 |
| Samsumg | Option 2 is preferred. |
| LG | We slightly support option 1. |
| InterDigital | We support support Option 3.  In our view, RxTx TEG is not necessary the same as the Rx +Tx TEG. Providing RxTx TEG associated with Rx-Tx time difference can help the LMF to accurately get rid of the timing error at the UE side. |
| ZTE2 | To QC:  Firstly, your example shows the TEG varies with time. However, we believe that TEG can be determined through the dimension of panel and frequency, not time. Timing error shift over time can be solved according to the definition of measurement instance.  Secondly, regarding your question ‘**So, how will the LMF know that the RxTx Errors are similar between those measurements if the RxTEG-IDs and TxTEG-IDs are different?’**, we think UE can report its RX TEG, Tx TEG combinations to LMF as a UE capability in advance. So LMF will know which Tx TEGs and which Rx TEGs can be seen as a combination and has the same Rx+Tx timing error. |

### Proposal 3.3-2 (H)

* For mitigating UE Tx/Rx timing errors for DL+UL positioning, support one of the following options for the UE to provide the association information of UE Tx TEG with the UL Positioning SRS resources to LMF:
  + Option 1: the association information is sent directly from UE to LMF
  + Option 2: the association information is sent first to the serving gNB and then forwarded from serving gNB to LMF
* FFS: the details of the signalling, procedures, and UE capability

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| ZTE | Support option 1 for DL+UL positioning. |
| OPPO | A common solution for Proposal 3.2-1 and 3.3-2 should be ensured. |
| CATT | Support Option 1. |
| vivo | Option1. Similar views as UL-TDOA. |
| Ericsson | The possibility to configure the UE to send UL SRS TX TEG association directly to the serving gNB should be supported primarily for UL TDOA purposes but could be used also for DL+UL positioning. For multi-RTT positioning the most efficient way to do this is, however, to signal the UL SRS TX TEG association together with the UE Rx-Tx time difference measurement in the multi RTT measurement report. We would be supportive of the following formulation:  Option 1b: The UE TX TEG association information for the UL SRS used for TX timing in a UE Rx-Tx time difference measurement is included together with the UE Rx-Tx time difference measurement in the multi-RTT measurement report. |
| Qualcomm | Option 1. Single solution for both UTDOA and RTT is preferred. |
| Apple | Support Option 1 |
| Nokia/NSB | Agree with Ericsson and support their option 1b in principle. |
| SONY | Option 1 |
| Huawei, HiSilicon | We think that it is important to allow for the UE not supporting LPP protocol but can have positioning feature. |
| CMCC | We support Option 1. |
| Samsung | Similar as above, option 1 is slightly preferred. |
| LG | Option 1. |
| InterDigital | Support Option 1 for the reason similar to Proposal 3.2-1. |

### Proposal 3.3-3 (H)

* For mitigating gNB Tx/Rx timing errors for DL+UL positioning, adopt one of the following options:
  + Option 1:
    - Support a gNB to provide the association information of a gNB Rx-Tx time difference measurement with a pair of TRP {Rx TEG, Tx TEG} to LMF, where the Rx TEG is used to receive the UL positioning SRS and the Tx TEG is used to transmit the DL PRS;
  + Option 2:
    - Support a gNB to provide the association information of a gNB Rx-Tx time difference measurement with a TRP RxTx TEG to LMF. The TRP RxTx TEG is associated with one or more {UL Positioning SRS resource, DL PRS resource} pairs
      * FFS: whether the gNB provides the association information of UL Positioning SRS resources to TRP Rx TEG to LMF for gNB RxTx measurements specifically
  + Option 3:
    - Support a gNB to provide the association information of a gNB Rx-Tx time difference measurement with a TRP RxTx TEG to LMF. The TRP RxTx TEG is associated with one or more TRP {Rx TEG, Tx TEG} pairs where the Rx TEG is used to receive the UL Positioning SRS and the Tx TEG is used to transmit the DL PRS.
* FFS: the details of the signalling, procedures, and UE capability

Comments

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| **Company** | **Comments** |
| ZTE | Support option 1 for consistency. |
| OPPO | Ok to further discuss it. Option 1 is preferred. |
| CATT | Support option1. In our point of view, it will make the signalling for mitigating UE Rx/Tx timing errors more complicated and increase the overhead, if RxTx TEGs are introduced for DL+UL positioning methods. |
| Ericsson | We don’t see the need for a gNB TEG (see discussion in our RAN4 contribution). Among the options above, we prefer option 1. |
| Qualcomm | As discussed in Proposal 3.3-1, same argument and figure. We consider RxTx TEGs really essential to be reported. |
| Apple | Option 2 is preferred |
| Nokia/NSB | Support Option 2. |
| SONY | Prefer option 1 |
| CMCC | We support Option 3. |
| Samsung | Similar as above UE one, we support option 2. |
| LG | We slightly support option 1. |
| InterDigital | Support Option 3 for the reason similar to Proposal 3.3-1 |

### Proposal 3.3-4

* + Support the use of the SRS resource(s) in the most recent SRS instance in advance of the Rx-Tx time difference measurement to derive RxTx TEG or Tx TEG in { Rx TEG, Tx TEG } pairs for Rx-Tx time difference measurements.

Comments

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| **Company** | **Comments** |
| OPPO | For UE side: Postpone it until we have any conclusion for Proposal 2.2-1 since they are coupled with each other.  For gNB side: the SRS used for the measurement should be used to derive the TEGs. |
| vivo | Support, only if actual SRS transmission is used to derive RxTx TEG or Tx TEG in {Rx TEG, Tx TEG} pairs.  If actual SRS transmission is used to derive RxTx TEG or Tx TEG in {Rx TEG, Tx TEG} pairs, we should clarify how the SRS resource for deriving RxTx TEG or Tx TEG in { Rx TEG, Tx TEG } pairs is obtained e.g. which SRS occasion to associate with the SRS resource; since from the definition of Rx-Tx time difference, the ‘Tx time’ in ‘Rx-Tx time difference’ is determined by the time of the UL subframe that is closest in time to the receiving time of PRS resource which is not associated with actual SRS transmission. |
|  |  |

### Proposal 3.3-5

* + Support TRPs to report RX+TX group delay measurement to solve the inter-TRP transmission and receiving timing difference mathematically at the location server
  + Support UE to report RX+TX group delay measurement for each pair of {RX TEG, TX TEG} to solve transmission timing difference between TX TEGs and receiving timing difference between RX TEGs mathematically at the location server.

Comments

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| **Company** | **Comments** |
| OPPO | How does UE know the group delay? If it know the group delay, UE can do calibration. |
| MTK | 1, to OPPO, UE can perform self calibration to learn RX+TX group delay, but UE can’t perform self calibration to learn RX or TX group delay. So when UE knows RX+TX group delay through self calibration, UE still doesn't know RX group delay is, and TX group delay is.  2, UE cares about RX group delay difference between two RX TEGs, and TX group delay difference between two TX TEGs.  3, In proposal 3.1-3, UE measures same TRP signal simultaneously by 2 RX TEGs. What we worry is, it doesn't guarantee the 2 RX TEGs could have good RSRP level, because the receiving beam direction of the 2 RX TEGs could be quite opposite. We are thinking another solution to calculate RX group delay difference between 2 RX TEGs and TX group delay difference between 2 TX TEGs, when RX+TX group delays are measured for each {RX TEG, TX TEG} pair.  The concept is like, we learn 10, but we don't know it is 6 (RX1) +4 (TX1), and we also learn 7, but we don't know it is 4(RX2) + 3(TX2). We can further derive RX1-RX2 = 2, and TX1-TX2 = 1, through the value of 10 and 7, and by DL-TDOA and UL-TDOA measurement  For TDOA technique, at UE side, we care about RX1 - RX2, and TX1 - TX2  Our proposal is not for DL+UL positioning, instead, it is to assst UE to improve DL-TDOA, and UL-TDOA.  To FL, we don't think it is proper to put the proposal in 3.3. Is it okay to move our proposal to 3.1 and 3.2? |
| SONY | Support. Not all UE can do calibration. If the UE has performed calibration then the LMF needs to be informed. |
| CATT | Support. |
| Huawei, HiSilicon | Just would like clarify the understanding from our side based on the proposal:  TRP1 will report its round trip time delay T1+R1, and TRP 2 will report its own T2+R2.  From UE side, UE has 2Tx and 2Rx, but here the proposal is to address the case that partial RTT measurement is conducted, e.g. UE knows t1+r1, and t2+r2, but UE does not know those cross-terms, e.g. t1+r2, t2+r1, right? Otherwise UE will be able to compenstate its Tx timing error and Rx timing error.  Given the condition, using DL-TDOA + UL-TDOA, associated with the information from TRPs (T1+R1, T2+R2), or from the UE (t1+r1, t2+r2), and the related RSTD and UL-RTOA measurements associated with the correct RxTEG and TxTEG, LMF will be able to mitigate the inter-gNB group delay error without deploying the reference device? |
| MTK2 | Respond to Huawei:  1, Yes, UE can only learn t1+r1 and t2+r2 through self calibration, and UE can not know t1+r2, t2+r1  2, Yes, DL-TDOA+UL-TDOA doesn't need to rely on reference device. Or the inter-gnb group delay error can be learned through reference device, and then this information can assist LMF to figure out UE side RX group delay difference (r1- r2) , and TX group delay difference (t1- t2), if UE can measure t1+r1, and t2+r2  In our view, to learn r1-r2 through measuring same TRP signal may not always be successful. This is because each panel’s beam direction would be quite opposite, and therefore, the beam of 2 panels may not always have the chance to aim at same TRP. It depends on probability.  Also, if UE and gNB also support RTT technique, the ability of RX+TX group delay measurement is needed. Otherwise, we don't need to talk about Rel-17. Rel-16 UE is enough  We just think that, if UE can measure RX+TX group delay, it can further help to learn r1- r2, and t1 –t2. We understand that UE may require some additional circuit. But for IIOT device, it could be feasible since the IIOT device doesn't require complicated band combination. |

### Proposal 3.3-6

* + Support to configure the UE to perform multi UE-RX-TEG - UE RX-TX time difference measurements, i.e. one UE RX-TX time difference measurement for each UE RX TEG and TRP.

Comments

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| **Company** | **Comments** |
| OPPO | Low priority |
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## Variations of Rx/Tx timing errors and error statistics of TEGs

Submitted Proposals

* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 7: The UE should provide the information of the UE Tx TEG(s) change associated with SRS resource(s) to the LMF, when the UE Tx TEG associated with SRS resource(s) changes, e.g. due to switching of UE antenna panel to avoid blockage.
  + The UE can provide this information based on event-triggerred reporting
* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 8: The information of the UE Tx TEG and Tx TEG change information associated with SRS resource(s) should also be provided to the gNBs performing RTOA measurement, to prevent the gNBs joint processing on different SRS measurement time occasions associated with different UE Tx TEGs for the same SRS resource(s).
  + After the LMF obtains the information of UE Tx TEG(s) change, it can further transmit this information to the gNB performing RTOA measurement
* (CMCC, [R1-2104611](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104611.doc)[5]) Proposal 2: Support UE to report the statistics (variance) of differences of the RX TEGs to LMF for mitigating TRP Tx timing errors and/or UE Rx timing errors for DL TDOA
* (CMCC, [R1-2104611](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104611.doc)[5]) Proposal 3: Support a UE to provide the statistics (variance, bound, etc.) of the Tx timing error differences between Tx TEGs to LMF
* (Qualcomm, [R1-2104671](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104671.doc)[6]) Proposal 2: With regards to TEG Information reporting, a device (UE or gNB) should be able to provide TEG-ID consistency information (e.g., a flag when TEG IDs are being reset). This applies to both Tx TEG, Rx TEG for both UEs and gNBs.
* (Qualcomm, [R1-2104671](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104671.doc)[6]) Proposal 7: For mitigating timing errors in DL-TDOA, UL-TDOA or DL+UL Positioning:
  + Support providing at least a timing Error uncertainty/margin associated with a TEG ID
  + Consider supporting in addition an average timing error associated with a TEG ID.
* (InterDigital, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[8]) Proposal 5: Support the LMF to configure a maximum difference between any two timing errors within a TEG.
* (InterDigital, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[8]) Proposal 10: For UE-B positioning methods, support the UE to request the information of gNB TEG.
* (InterDigital, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[8]) Proposal 11: Support a UE to indicate TEG in the measurement reporting when TEG information is changed compared to the previous reporting.
* (Apple, [R1-2105105](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105105.doc)[10]) Proposal 2: At least for UE-based method, LMF will provide the effective error to UE, e.g., through the LPP message Provide Assistance Data, or it may ask gNB to broadcast the effective error within posSIB
  + Each effective error value may be associated with a set of TRP IDs of candidate NR TRPs for measurement
* (Apple, [R1-2105105](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105105.doc)[10]) Proposal 3: UE will indicate, e.g., through LPP message Provide Location Information, to the LMF whether or not the effective error is compensated/applied to the positioning measurements and/or location calculation
* (Sony, [R1-2105168](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105168.doc)[11]) Proposal 3: Support the time-varying property of TEG. The association information can be used to identify the TEGs at different time.
* (Samsung, [R1-2105310](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105310.doc))[12]) Proposal 3: For indication of TEG in UL-TDOA, a time domain resource (e.g. a slot) containing the TEG (associated with the corresponding SRS-pos is supported.
* (MTK, [R1-2105759](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105759.doc)[16]) Proposal 3-5: For DL-RSTD measurement, the statistics (variance) of RX group delay difference at UE which are related to different frequency layers for receiving, or different RX TEGs for receiving may report to the location server
* (Fraunhofer, [R1-2105856](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105856.doc) [17]) Proposal 4: Support a TRP to provide the statistics (variance, bound, etc.) of the Tx timing error and Rx timing errors within one TEG to LMF.
* (Fraunhofer, [R1-2105856](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105856.doc) [17]) Proposal 6: Support a UE to provide the statistics (variance, bound, etc.) of the Tx timing error and Rx timing errors within one TEG to LMF.
* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 7 TX TEG association reports should have a configurable periodicity and the reports should include the UE TX TEG association of each transmission occasion of each SRS resource during the reporting period.
* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 14 In NR Rel-17, support the UE to associate both a spatial and a temporal UE RX TEG index to each TOA measurement and to indicate both these indices in RSTD and UE RX-TX time difference measurements.
* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 15 In NR Rel-17, support the UE to associate both a spatial and a temporal UE TX TEG index to each UL SRS transmission and to signal the associated indices in a message to the LMF.
* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 16 Study how to handle frequency-dependent timing errors in NR Rel-17.

FL Comments

If a UE or a TRP has the statistical information related to Tx/Rx timing errors associated with the Rx/Tx TEGs, the information may be useful for the LMF/UE for the estimation of the UE position as proposed by multiple companies ([5][6][8][10][11][16][17][19]). Here, it is suggested to consider separately providing the error margins of Rx/Tx/RxTx TEGs and providing the difference of error margins between Rx/Tx/RxTx TEGs.

In addition, the timing errors of UE Rx/Tx TEGs may changes with time for various reasons as discussed by multiple companies (e.g., [2][6][8][11][19]). Thus, there is a need to consider how to handle the time-varying property of TEGs for information consistency.

### Proposal 3.4-1 (H)

* Subject to UE’s capability, support UE to provide the margin of the Rx timing errors of a UE Rx TEG to LMF for DL-TDOA
* Subject to UE’s capability, support UE to provide the margin of the Tx timing errors of a UE Tx TEG to LMF for UL- TDOA
* Subject to UE’s capability, support UE to provide the margin of the RxTx timing errors of a UE RxTx TEG to LMF for Multi-RTT if UE RxTx TEG is supported
* FFS: how the error margin is defined (e.g., The statistics of variance, the error bound (maximum timing error), etc.)

Comments

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| **Company** | **Comments** |
| OPPO | Not support  We don’t have any knowledge about the margin, e.g.., whether is a value for all UE or different UE can have different values. It is RAN4 issue. RAN1 can do nothting without any input from RAN4 |
| CATT | We only support the first and the second bullets, since we think whether introduce RxTx TEG needs further discussion. |
| vivo | We are not sure the margin can be determined in RAN1. |
| Ericsson | We do not support the above formulations. It’s the maximum timing error ***difference*** between different measurements/transmissions associated with the same TEG that is of interest, not the timing errors themselves. The margin (i.e. the maximum timing error *difference* between different measurements/transmissions associated with the same TEG) could be specified by RAN4. Possibly it could be different depending on UE capabilities or signaled as a UE capability. |
| Huawei, HiSilicon | We understand we defined “margin” in the TEG definition. However, how this margin is associated with the TEG error (difference) is not clear. For example, one can model the TEG error (difference) as Gaussian distribution, what would be the “margin” then? Should it be the sigma or 3 sigma of the Gaussian distribution? One also also model the TEG error as uniform distribution, in which case the margin could be the upper bound? |
| Qualcomm | Yes it is the maximum error difference between the measurements associated with the same TEG. I guess some reformulation is needed. Either way, having multiple options as UE capability and the flexibility to provide different margin will be forward compatible and more general, so we are generally supportive.  To HW: We don’t see the need really to go to such details in RAN1, especially at this stage.Maybe RAN4 could look into it. From RAN1 perspective, do we see the need to have a UE that says: “I support the feature assuiming a margin of X nsec” and another UE that says “Y nsec”? |
| Apple | Do not support (similar view as OPPO) |
| Nokia/NSB | We are in principle supportive. We think the UE can report the maximum assumed margin within some confidence margin (the confidence margin could be hard coded while the maximum timing margin is signaled, e.g., in capability signaling) |
| SONY | We have similar view as Ericsson. |
| ZTE | Do not support(similar view as OPPO) |
| Samsung | Not support. It depends on more discussion of TEG, e.g., RAN4 input.  Due to similar reasons, we are not yet really to support following proposal 2~5 as well. |
| LG | Do not support(similar view as OPPO) |
| InterDigital | We support the proposal.  We already agreed that TEG is defined as the transmission/reception, which has the timing error within a certain **margin**. If we just have one timing error per TEG, we do not need to define TEG. Having said that, if the UE is aware of the margn of the timing error, (Tx, Rx, or RxTx), it should provide to the network. |

### Proposal 3.4-2 (H)

* Support gNB to provide the margin of the Rx timing errors of a TRP Rx TEG to LMF for UL-TDOA
* Support gNB to provide the margin of the Tx timing errors of a TRP Tx TEG to LMF for DL- TDOA
* Support gNB to provide the margin of the RxTx timing errors of a TRP RxTx TEG to LMF for Multi-RTT if TRP RxTx TEG is supported
* FFS: how the error margin is defined (e.g., The statistics of variance, the error bound (maximum timing error), etc.)

Comments

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| **Company** | **Comments** |
| OPPO | Not support. Same comment as Proposal 3.4-1 |
| CATT | We only support the first and the second bullets, since we think whether introduce RxTx TEG needs further discussion. |
| vivo | We are not sure the margin can be determined in RAN1. |
| Ericsson | We don’t support the above formulations. It’s the maximum timing error ***difference*** between different measurements/transmissions associated with the same TEG that is of interest, not the timing errors themselves. |
| Huawei, HiSilicon | We understand we defined “margin” in the TEG definition. However, how this margin is associated with the TEG error (difference) is not clear. For example, one can model the TEG error (difference) as Gaussian distribution, what would be the “margin” then? Should it be the sigma or 3 sigma of the Gaussian distribution? One also also model the TEG error as uniform distribution, in which case the margin could be the upper bound? |
| Qualcomm | Similar comments above. There should not be an attempt to define numbers nor distrivutions.  Do we agree with the principle that different UEs/gNBs may have different margins? Or will the feature be a black/white scenario? Either the /gNBs meets a margin or no? We prefer to have some flexibility and different level of margins for forward compatibility. |
| Apple | Same comment as Proposal 3.4-1 |
| Nokia/NSB | Same comments as on Proposal 3.4.-1 |
| SONY | Same comments as on Proposal 3.4.-1 |
| ZTE | Same comments as on Proposal 3.4.-1 |
| LG | Same comments as on Proposal 3.4.-1 |
| InterDigital | Support |

### Proposal 3.4-3 (H)

* Support UE to provide the margin of the Rx timing error differences between UE Rx TEGs to LMF for DL-TDOA
* Support UE to provide the margin of the Tx timing error differences between UE Tx TEG to LMF for UL- TDOA
* Support UE to provide the margin of the RxTx timing error differences between UE RxTx TEG to LMF for Multi-RTT if UE RxTx TEG is supported
* FFS: how the margin of the error difference is defined (e.g., The statistics of variance, the error bound (maximum timing error), etc.)

Comments

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| --- | --- |
| **Company** | **Comments** |
| OPPO | Not support. Same comment as Proposal 3.4-1 |
| CATT | We only support the first and the second bullets, since we think whether introduce RxTx TEG needs further discussion. |
| Vivo | We are not sure the margin can be determined in RAN1. |
| Ericsson | We don’t support the above formulations. It’s the maximum timing error difference between different measurements/transmissions associated with the ***same*** TEG that is of interest. The margin (i.e. the maximum timing error difference between different measurements/transmissions associated with the ***same*** TEG) could be specified by RAN4. Possibly it could be different depending on UE capabilities or signaled as a UE capability. |
| Huawei, HiSilicon | We understand we defined “margin” in the TEG definition. However, how this margin is associated with the TEG error (difference) is not clear. For example, one can model the TEG error (difference) as Gaussian distribution, what would be the “margin” then? Should it be the sigma or 3 sigma of the Gaussian distribution? One also also model the TEG error as uniform distribution, in which case the margin could be the upper bound? |
| Qualcomm | Similar comments above. There should not be an attempt to define numbers nor distrivutions.  Do we agree with the principle that different UEs/gNBs may have different margins? Or will the feature be a black/white scenario? Either the /gNBs meets a margin or no? We prefer to have some flexibility and different level of margins for forward compatibility. |
| Apple | Same comment as Proposal 3.4-1 |
| Nokia/NSB | Don’t support. |
| SONY | Do not support |
| ZTE | Same comments as on Proposal 3.4.-1 |
| LG | Same comments as on Proposal 3.4.-1 |
| InterDigital | Support |

### Proposal 3.4-4 (H)

* Support gNB to provide the margin of the Rx timing error differences between TRP Rx TEGs to LMF for UL-TDOA
* Support gNB to provide the margin of the Tx timing error differences between TRP Tx TEG to LMF for DL- TDOA
* Support gNB to provide the margin of the RxTx timing error differences between TRP RxTx TEG to LMF for Multi-RTT if TRP RxTx TEG is supported
* FFS: how the margin of the error difference is defined (e.g., The statistics of variance, the error bound (maximum timing error), etc.)

Comments

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| --- | --- |
| **Company** | **Comments** |
| CATT | We only support the first and the second bullets, since we think whether introduce RxTx TEG needs further discussion. |
| vivo | We are not sure the margin can be determined in RAN1. |
| Ericsson | We do not support the above formulations. It’s the maximum timing error difference between different measurements/transmissions associated with the ***same*** TEG that is of interest. |
| Huawei, HiSilicon | We understand we defined “margin” in the TEG definition. However, how this margin is associated with the TEG error (difference) is not clear. For example, one can model the TEG error (difference) as Gaussian distribution, what would be the “margin” then? Should it be the sigma or 3 sigma of the Gaussian distribution? One also also model the TEG error as uniform distribution, in which case the margin could be the upper bound? |
| Apple | Same comment as Proposal 3.4-1 |
| Nokia/NSB | Don’t support. |
| ZTE | Same comments as on Proposal 3.4.-1 |
| LG | Same comments as on Proposal 3.4.-1 |
| InterDigital | Support |

### Proposal 3.4-5 (H)

* UE/gNB should provide the updates of the Rx/Tx/RxTx TEG information to LMF whenever the previously provided TEG information is no longer valid.
* Support one of the following options for the update of Rx/Tx/RxTx TEG information:
  + Update or reset of Rx/Tx/RxTx TEG IDs;
  + Including a timestamp (or temporal index) in Rx/Tx/RxTx TEG information and update the timestamp (or temporal index) when it is necessary.
* FFS: How UE/gNB determines the previous TEG information is invalid (e.g., up to UE/gNB implementation)

*Comments*

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| **Company** | **Comments** |
| OPPO | Not support  We don’t have any knowledge about TEG, e.g., validation of a TEG. It is RAN4 issue. RAN1 can do nothting without any input from RAN4 |
| CATT | Not sure the benefits of such scheme. We prefer to put this issue as low priority. |
| Ericsson | The solution need to be able to handle both discontinuous processes like timing adjustments and continuous processes like clock drifts. This could be achieved either by  a) The combination of timestamps and TEG resets where the TEG reset is used only in case of discontinuous events like timing adjustments  b) A UE counter which is increased like a clock to handle continuous processes and increased multiple steps in case of a discontinuous event like a timing adjustment. The counter value at the time of the measurement would be included in the measurement report. |
| Qualcomm | Generally supportive, the specific solutions that E// is showing can be discussed later on.  ***Support UE/gNB to provide updates of the Rx/Tx/RxTx TEG information to LMF whenever the previously provided TEG information is no longer valid.***   * ***FFS: Signaling details***   To CATT: The benefit is that we avoid confusion of how long are the “TEG Information” valid. If the UE reports a 1st measurement associated with TEG-1 and reports a 2nd measurement with TEG-1, if these 2 measurements are in different reports or even in the same report but different timestamp, does it mean that they really have timing errors that are similar? How does CATT plan to address this issue? |
| Apple | Same comment as Proposal 3.4-1 |
| Nokia/NSB | Open to discuss this further but feel that we need to make progress on other topics above first before we can move to this level of discussion. |
| SONY | Support. The LMF needs to be sure that the TEG information is still valid. Inaccurate/invalid TEG information degrades the positioning accuracy. |
| ZTE | Support Nokia’s view that we should discuss it later. |
| LG | We are open to discuss it as a low priority. |
| InterDigital | We support the proposal. In our view, the UE does need always provide the TEG information. Instead, the TEG information is necessary if the previously provided TEG is no longer valid. This topic is a general subject so it can be discussed along with other issues. |

# Reference devices for mitigating UE/gNB Tx/Rx timing errors

Background

The following agreement was made in RAN1#104e related to the use of a reference device with a known location to support the mitigating UE/gNB Tx/Rx timing errors:

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| Agreement:   * Study specification impact for enabling a reference device with known location to support the following functionalities:   + Measure DL PRS and report associated measurements (e.g., RSTD, Rx-Tx time difference, RSRP) to the LMF;   + Transmit SRS and enable TRPs to measure and report measurements (e.g., RTOA, Rx-Tx time difference, AOA) associated with the reference device to the LMF;   + FFS: The details of the behavior, the measurements, the parameters related to the Rx and Tx timing delays, AoD and AOA enhancements and measurement calibrations;   + FFS: The report of device location coordinate information to the LMF if the LMF does not have the information   + FFS: The device with the known location being a UE and/or a gNB   + FFS: Precision to which location of reference device is known * Note: RAN1 assumes using these enhancements for the purpose of network synchronization is NOT within the scope of the WI |

The specification impact for enabling a reference device with a known location for the enhancements of the positioning performance was discussed internsively in RAN1#104bis-e without conclusion. The following is the latest version of the proposal for discussion in FL summary [21].

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| Proposal 4-1 (Revision 5) (H)  * RAN1 has evaluated the use of reference devices, which can either be UE or TRP, for positioning and observes improvements in using reference devices for enhancing the positioning performance.   + Note 1: The position of the reference device is known;   + Note 2: If the device is a TRP, it needs at least to support some of the Rel-16 positioning functionalities, which will be defined by RAN2. For example, the device positioning functionalities may include, but not limited to, the following:     1. Provide the positioning measurements (e.g., RSTD, RSRP, Rx-Tx time differences)     2. Transmit the UL SRS signals for positioning   + Note 3: If the device is a UE, it may be requested by the LMF to provide its own known location coordinate information to the LMF. If the antenna orientation information of the device is known, the information may also be requested by the LMF;   + Note 4: The impact on the specification, the measurement reports, and the procedure for supporting a UE/TRP to be a reference device will be determined by RAN2/RAN3/SA2;   + Note 5: Up to RAN2/RAN3 discussions what type(s) of UE/TRP can be reference devices and any capabilities if/as needed   + Note 6: RAN1 has not identified specification enhancements needed in RAN1 specifications * Send an LS to RAN2/RAN3/SA2 once RAN1 reaches the agreement for the above proposal and kindly asks RAN2 and RAN3 to determine if and what specification enhancements are needed in the relevant WGs to enable reference devices for positioning. |

Submitted Proposals

* (Huawei [R1-2104277](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104277.doc)) Proposal 6: Support to reuse the LPP signaling to provide the location coordinate information of the reference UE and add a new location source to indicate where the information come from.
* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 16:
  + Support to introduce new type of reference device, rather than normal UE or gNB/TRP, for Rx/Tx timing error mitigating.
    - it should have the ability to obtain and provide its own location with high accuracy and confidence
    - it may also be requested by the LMF to provide its own location information to the LMF
    - it should support basic positioning functionalities, such as providing the positioning measurements and transmitting the UL SRS for positioning.
  + Note: it is up to RAN2/RAN3 to further define ‘the entity’, architecture and signalings for this new type of reference device.
* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 17: Support the ‘reference device’ being controlled by the LMF for better assisting network calibration, e.g., including
  + support the LMF to indicate the use of Rx TEGs or Tx TEGs of the ‘reference device’
  + support the LMF to indicate the mobility or the motion trajectory of the ‘reference device’
* (vivo, [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc)[2]) Proposal 18: The location information of ‘reference device’ can be provided to the gNB for angle error calibration by itself.
* (CATT, [R1-2104520](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104520.doc)[3]) Proposal 16: NR Rel-17 should support reporting the location coordinate information of reference UE from UE to LMF for mitigating the Rx/Tx timing error of UE/TRPs, with the double differential positioning method.
* (CATT, [R1-2104520](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104520.doc)[3]) Proposal 17: NR Rel-17 should support reference UE and target UE using the same way of signalling of DL/UL reference signal, and reporting the measurements for compensation the Rx/Tx timing error of target UE /TRPs, with Rel-16 DL/UL-TDOA / Multi-RTT positioning method.
* (CATT, [R1-2104520](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104520.doc)[3]) Proposal 18: NR Rel-17 should support reference UE reporting the value of Rx/Tx timing error difference between different TRPs to LMF for UE-assisted positioning or to target UE via LMF for UE-based positioning.
* (CATT, [R1-2104520](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104520.doc)[3]) Proposal 19: NR Rel-17 should support reporting the parameters related to gNB Rx/Tx timing error from gNB to LMF for UE-assisted positioning (or from gNB/LMF to UE for UE-based positioning).
* (CATT, [R1-2104520](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104520.doc)[3]) Proposal 20: The following approaches can be supported to obtain the location coordinates of a reference device.
  + The reference device is placed in a known position.
  + The location of reference UE is calculated by RAT-independent positioning scheme (such as GPS etc.).
  + The reference device is selected/placed at the location of a TRP with a known position.
* (CMCC, [R1-2104611](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104611.doc)[5]) Proposal 1: From RAN1 perspective, support enabling a reference device with known location to mitigate and calibrate the timing/angle errors.
* (Qualcomm, [R1-2104671](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104671.doc)[6]) Proposal 8: Support a device to be used as a “Reference Location Device (RLD)”.
  + Up to RAN2 to continue the specification work (and how/if to enable a UE/gNB to be a RLD).
* (OPPO, [R1-2104739](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104739.doc)[7]) Proposal 12: Implementation based approach (Approach 2) is supported for the positioning based on reference device(s) with known location.
* (InterDigital, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[8]) Proposal 1: Specification impact of reference devices includes at least assistance information which contains at least reference device ID, locations of reference devices.
* (InterDigital, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[8]) Proposal 2: Study positioning procedures to support differential positioning techniques.
* (InterDigital, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[8]) Proposal 3: A reference device is classified as a UE.
* (InterDigital, [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc)[8]) Proposal 4: Do not support features to allow enlistment of reference device(s) during the initial phase of reference-based positioning standardization study/work.
* (Intel, [R1-2104905](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104905.doc)[9]) Proposal 3: Support solution, where reference device is a UE, which may provide the following information based on the extended capabilities:
  + It may be requested by LMF to provide its own known location coordinate information to LMF
  + It may be requested by LMF to provide its antenna orientation information to LMF, if this information is available
* (Intel, [R1-2104905](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104905.doc)[9]) Proposal 4: Continue discussion on reporting format of the precisely known reference UE location coordinates from UE to LMF and whether additional indication/signaling is needed so that LMF can distinguish reference and basic UEs
  + FFS: the details of the signaling, procedures
* (Intel, [R1-2104905](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104905.doc)[9]) Proposal 5: Specify reporting format of the reference UE antenna orientation in space from UE to LMF
  + FFS: the details of the signaling, procedures
* (Apple, [R1-2105105](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105105.doc)[10]) Proposal 1: A reference device and any required specification is exclusively defined for a TRP, not a UE.
* (Sony, [R1-2105168](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105168.doc)[11]) Proposal 4: Support to introduce reference device identification based on the device capability, which is to enable the LMF to select the capable devices (UE/gNB) to be reference device.
* (Sony, [R1-2105168](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105168.doc)[11]) Proposal 5: Support to further study the signaling mechanism between reference device and LMF during the reference UE identification phase. Location uncertainty, location acquisition source and mobility of a candidate reference device can be considered as the factors of capability.
* (Nokia, R1-2105512[14]) Proposal 4: RAN1 to specific support for enabling a selected device with known location to support configuration by the network for at least some positioning calibration measurements.
* (MTK, [R1-2105759](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105759.doc)[16]) Proposal 3-3: The inter-TRP transmission timing difference could be measured by the reference UE. Same measurement reporting as the normal UEs is expected. LMF may handle the extraction of the inter-TRP transmission timing difference from the measurement reports.
* (Lenovo, [R1-2105859](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105859.doc)[18]) Proposal 1: RAN1 to continue reference device discussions based on the FL’s latest version of the proposal (Revision 5) made during the RAN1#104-bis-e meeting.
* (Lenovo, [R1-2105859](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105859.doc)[18]) Proposal 2: Existing LPP procedures can be used to support reference devices. Other WGs such as RAN2/RAN3/SA2 can be consulted for feasibility and specification impacts.
* (Lenovo, [R1-2105859](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105859.doc)[18]) Proposal 3: Reference UE can report its location estimate information using existing LPP signalling methods or offline calibration methods.
* (Lenovo, [R1-2105859](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105859.doc)[18]) Proposal 4: Reference UE can include positioning QoS information as part of its location estimate report to determine the quality/uncertainty of the location estimate.
* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 21 No reference device should be specified in Rel. 17.

FL Comments

Based on the proposals submitted to this meeting, it seems to enable a reference device with a known location for the enhancements of the positioning performance is still supported by a majority of companies with the discussion of the benefits and potential impacts on the specification (e.g., [1][2][3][5][6][8][9][11][14][16][18]). However, there are still some different views. One of them is that the support of the feature has no specification impact [7][19], and another view is that UE’s location may not be known precisely.

Considering that the common view of the main specification impact is not in RAN1, but in other WGs, one possible way forward to conclude the discussion is to send an LS to RAN2/RAN3/SA2, informing them that RAN1 has discussed the issue, determined that there is no impact in RAN1 specification, and ask RAN2/RAN3/SA2 to take a look at the issue and determine whether there is any specification on their specifications. enhancements are needed to enable the reference UE/TRP for positioning. Proposal 4-1 is prepared in the following based on the consideration of the proposals submitted to this meeting and also the discussion in RAN1#104bs-e [21].

### Proposal 4-1 (H)

* Send an LS to RAN2/RAN3/SA2, including the following content:
  + RAN1 has evaluated the use of reference devices with known locations for positioning and observes improvements in using reference devices for enhancing the positioning performance. But, RAN1 has not identified specification enhancements needed in RAN1 specifications. RAN1 kindly asks RAN2/RAN3/SA2 to determine if and what specification enhancements are needed to enable the reference UE/TRP for positioning.
  + Notes:
    1. The reference device can either be a UE or a TRP. It is up to RAN2/RAN3 to decide what type(s) of UE/TRP can be reference devices;
    2. If the device is a TRP, it is expected to support, at least, some of the Rel-16 positioning functionalities of UE, which will be defined by RAN2. The positioning functionalities may include, but not limited to, the following:
       - Provide the positioning measurements (e.g., RSTD, RSRP, Rx-Tx time differences)
       - Transmit the UL SRS signals for positioning
    3. If the device is a UE, it may be requested by the LMF to provide its own known location coordinate information to the LMF. If the antenna orientation information of the device is known, the information may also be requested by the LMF. It is up to RAN2 to determine any UE capabilities if/as needed.

Comments

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| **Company** | **Comments** |
| ZTE | Support FL’s proposal |
| OPPO | Some question for clarification:  1. Is the refernce device is a stationary device or a mobile device?  2. How does a refernce UE get the known location? If the refernce UE can get the known location via GNSS, why other UE cannot use GNSS to get it location?  3. How does UE know its antenna orientation information?  4. Based on RAN1 evaluation, what’s the impact of the group timing delays of reference devices on the performance? |
| CATT | Support FL’s proposal. We believe the reference devices are very important for the accuracy improvements of positioning. |
| vivo | To FL: as described in our contribution, new type of reference device rather than normal UE or gNB/TRP is discussed, we think it cannot be excluded by RAN1 and needs to be further determined by other groups. So, we suggest adding ‘new type of reference device rather than normal UE or gNB/TRP’ in Note 1. |
| Ericsson | We do not support the proposal in the current form. To study a TRP with Rel-.16 UE positioning functionalities is far outside the scope of the work item and if the proponents want this to be studied they should bring a proposal to the RAN plenary. If the content of the LS is limited to the use of a UE as reference device it may be possible to agree on some formulation.  We note that many companies seem to be interested in the use of UEs as reference device while only a few are interested in using a TRP. |
| Lenovo,Motorola Mobility | Support FL’s proposal. On the other hand, we can also live with Ericsson’s suggestion of focusing the proposal on UEs as reference device for the sake of progress. |
| QC | Support. |
| Nokia/NSB | Support. We are okay with UE only as a compromise as suggested by Ericsson. |
| SONY | Support |
| CMCC | Support. |
| Samsung | Fine. |
| LG | Support |
| InterDigital | Support FL’s proposal |

# Measurement enhancements for mitigating UE/gNB Tx/Rx timing errors

Background

The following agreement was made in RAN1#104e related to the measurement enhancements for mitigating UE/gNB Tx/Rx timing errors:

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| Agreement:  Support enabling   * A UE to report one or more measurement instances (of RSTD, DL RSRP, and/or UE Rx-Tx time difference measurements) in a single measurement report to LMF for UE-assisted positioning, and * A TRP to report one or more measurement instances (of RTOA, UL RSRP, and/or gNB Rx-Tx time difference measurements) in a single measurement report to LMF, and * Each measurement instance is reported with its own timestamp   + FFS: The measurement instances are within a [configured] measurement time window * FFS: Each UE measurement instance can be configured with N instances of the DL-PRS Resource Set   + FFS: N (including N=1) * FFS: Each TRP measurement instance can be configured with M SRS measurement time occasions   + FFS: M (including M=1) * FFS: details of behavior, procedures, and UE capability if any * FFS: whether and how to consider the additional enhancement related to measurement reporting of multi-paths and quality metric * Note 1: A measurement instance refers to one or more measurements, which can either be the same or different types, which are obtained from the same DL PRS resource(s), or the same UL SRS resource(s). * Note 2: This enhancement has no intention to change the mapping of measurement types to Rel-16 positioning techniques and no intention to introduce new positioning techniques either. |

FL Comments

In RAN1#104e, it was agreed that a UE/TRP will support reporting one or more measurement instances in a single measurement report, and each measurement instance is reported with its own timestamp. In RAN1#104bis-e, there was only very limited discussion on this topic due to the TU limitation.

In this meeting, many companies have presented their views on the report of one or more measurement instances in a single measurement report, especially on the FFSs in the above agreement, which are summarised as follows:

* About the measurement time window for the measurement instances:
  + In [3], CATT proposes:
    - The measurement time windows should be configurable.
    - UE measurement time windows and TRP measurement time windows can be configured independently. They can be configured to be the same or different
    - UE (or TRP) is not expected to measure DL-PRS (or SRS-Pos) outside of the measurement time window.
  + In [3] CATT proposes two methods for the configuration of the measurement time window (MTW) for UE/TRP with the definitions of the length of UE/TRP MTWs of these methods:
    - For Method 1, MTW is configured with the periodicity, the start time, and end time of UE/TRP (for periodic MTW).
    - For Method 2, MTW is configured with is the periodicity, the start time, and duration
  + In [6], Qualcomm proposes support LMF sending a “Time-domain Window” configuration(s) to both UE and gNBs: Each window is defined with a start/End configuration. The device (UE/gNB) is expected to perform measurements and reporting that start no earlier than the startTime, and perform measurements no later than the EndTime.
  + In [6], Qualcomm proposes to study further the UE behavior when a limited number (or none) of PRS instances appears within a configured time-domain window.
  + In [13], LG proposed to introduce measurement acquisition rules on
    - UE Rx-Tx time difference measurement and gNB Rx-Tx time difference measurement
    - RSTD measurement and UE/gNB Rx-Tx time difference
  + In [14], Nokia proposes UE to provide gNB its measurement time window for UE Rx-Tx time difference measurement.
  + In [18], Lenovo proposes
    - The time group selection or measurement window can be associated with an ID, identifying all associated timestamps for all measurement instances within the time group selection/ measurement window for easier processing and management at the LMF.
    - Length of the DL-PRS time group selection/measurement time window should be based on a number of occasions and (N,T) DL-PRS processing UE capability.
  + In [19], Ericsson proposed it shall be possible to configure the measurement window for a measurement instance to be so short that there is no risk for the TEG associations to change during the measurement window.

**FL:** Further discussion in Proposal 5-1.

* About the timestamp for a measurement instance:
  + In [1], Huawei proposes support for a single report containing multiple measurement instances, and specifying the time stamp selection for each measurement instance and scattering the measurement instances throughout the measurement time;
  + In [2], vivo proposes the UE or the TRP can be configured to report one or more measurement instances in a single measurement report to the LMF,
  + In [2], vivo proposes to enable the UE to report PRS measurements derived from the most recent measurement instances in advance of a certain time before the measurement report. The certain time before the measurement report is related to PRS processing capability.
  + In [3], CATT proposes
    - The timestamp of the UE measurement instance corresponds to any of the time instances between the first and the last DL-PRS resource set contained by the measurement instance;
    - The timestamp of the TRP measurement instance corresponds to a time instance between the first and the last SRS-Pos resource set contained by the instance.
  + In [4], ZTE proposes the time stamp is a time window indicated by,
    - A starting timestamp that corresponds to a reception time of the first reference signal for determining a measurement instance, and
    - An ending timestamp that corresponds to a reception time of the last reference signal for determining the measurement instance.
  + In [18], Lenovo proposes:
    - the timestamp should correspond to the reception time of the last received PRS in a set of one or more measurement instances within a time group selection or measurement window.
    - The time group selection or measurement window can be associated with an ID, identifying all associated timestamps for all measurement instances within the time group selection/ measurement window for easier processing and management at the LMF.

**FL:** Further discussion in Proposal 5-2.

* About the UE measurement instances and the number of instances of the DL-PRS Resource Set,
  + In [4], ZTE proposes to consider a number of alternatives to configure the number of instances of DL PRS resource set in a UE measurement instance (i.e. the value N)
    - Alt 1: configured by LMF per DL PRS resource set.
    - Alt 2: configured by LMF per TRP.
    - Alt 3: configured by LMF per positioning frequency layer.
    - Alt 4: configured by LMF per measurement report.
  + In [6], Qualcomm proposes the support of LMF requesting the UE or gNB to perform measurements on specific PRS/SRS resources across multiple time-domain instances.

**FL:** The value “N” is one of the remaining issues in the previous agreement. Further discussion in Proposal 5-3.

* About the association between measurement instances and UE measurement report
  + In [4], ZTE proposes the following options
    - Option 1: multiple measurement instances are associated with the indicated DL PRS resource.
    - Option 2: For each indicated DL PRS resource set in a measurement report, multiple measurement instances are associated with the indicated DL PRS resource set.
    - Option 3: For each indicated measurement element (i.e. TRP) in a measurement report, multiple measurement instances are associated with the indicated measurement element.
    - Option 4: For each indicated positioning method in a measurement report, multiple measurement instances are associated with the indicated positioning method.
    - Option 5: Multiple measurement instances are directly associated with a measurement report.

**FL:** Further discussion in Proposal 5-4.

* About details of procedures, and UE capability
  + In [2], vivo proposes the relationship between ‘the number of DL-PRS Resources Set instances related to each UE measurement instance’ and ‘the number of PRS samples for RSTD/Rx-Tx time difference/PRS-RSRP measurements’ defined by RAN4’ should be clarified, and send an LS to RAN4 for consistent understanding.

**FL:** Not sure if we need to have the LS to RAN4 for this issue now. Further discussion in Proposal 5-5.

* + In [18], Lenovo proposes the existing UE timing quality indication can be extended to indicate the quality of timing-based measurement instances such as RSTD and UE Rx-Tx time difference measurements. FFS if the indication is applicable to one or more measurement instances.

**FL:** Further discussion in Proposal 5-6.

* About LPP/NRPPa signalling
  + In [7], OPPO, proposes:
    - The current LPP signaling can support the feature that UE reports one or more measurement instances in a single measurement report to LMF, with potential extension to support a larger number than 4.
    - No enhancement is needed for the current NRPPa signaling to support the feature that TRP reports one or more measurement instances with the same quantity in a single measurement report to LMF.
    - Enhancement on the association of measurement instances should be introduced to support the feature that TRP reports one or more measurement instances with different quantities in a single measurement report to LMF.

**FL:** Once RAN1 makes the decisions on the measurement instances and reports, we will send LS to RAN2/3/4. The impact on LPP/NRPPs signalling may be discussed in RAN2/3.

* About dditional enhancement related to measurement reporting of multi-paths and quality metric
  + (Intel, R1-2104871[9]) Proposal 6:
    - Support introduction of the LOS/NLOS indicator associated with the UE DL RSTD and UE Rx-Tx time difference measurements
    - Support introduction of the LOS/NLOS indicator associated with the gNB UL RTOA and gNB Rx-Tx time difference measurements

**FL:** Suggest the LOS/NLOS indicator to be discussed in AI 8.5.5.

### Proposal 5-1 (H)

* Support LMF to configure the measurement time window (MTW) for a UE for the measurement instances included in a measurement report. UE is expected to perform measurements during the configured MTW.
* Support LMF to configure the measurement time window for a gNB for the measurement instances included in a measurement report. gNB is expected to perform measurements during the configure MTW
* FFS: the details of the MTW configuration
* Note: UE/gNB’s behaviors outside of the MTWs are undefined

Comments

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| **Company** | **Comments** |
| ZTE | We think there is no need to define measurement time window. The time duration between two measurement report can be seen as a measurement time window. |
| OPPO | Measurement time window is not needed. Each measurement instance is reported with its own timestamp and LMF can know whether these measure instance is close enough or not. |
| CATT | Support FL’s proposal. The The measurement time window can help LMF to eliminate the influence of timing errors of TRPs and UE. The purposes for introducing measurement time window are as follows:   * Limit the measurement behaviour of UE or TRP, and only DL-PRS/ SRS-Pos resources within the measurement time window will be measured. * Limit the measurement time of each measurement instance, and support the measurement instance which only corresponds to one DL-PRS/SRS-Pos occasion for one-shot measurement. * Facilitate the timestamps matching among various measurement instances, e.g., among UE Rx-Tx time difference measurement instances and gNB Rx-Tx time difference measurement instances for multi-RTT positioning method. * Indicate whether the measurement instances are measured within the same measurement time window. * Help LMF to track and mitigate the timing error drift over time. |
| vivo | We wonder whether MTW is related to ‘schedule location time’ stated in the LS S2-2102048 from SA2. If it is, regarding ‘schedule location time’, companies have different understandings. And in the last meeting, RAN2 has identified many questions that need to be clarified by SA2. Therefore, the impact of schedule location time on the RAN side is still unclear. It is more appropriate to deal with this issue after RAN2 reaching a conclusion. |
| Ericsson | Not supportive of the proposal. We prefer the solution in Proposal 5-3. |
| Huawei, HiSilicon | Support in principle |
| Lenovo,Motorola Mobility | Support intention of the proposal but we view this in terms of the different sets of timestamps to be reported for easier management at the LMF. The LMF should be able to distinguish one set of timestamps of one or multiple measurement instances with another set of timestamps associated with multiple measurement instances. These sets may not be overlapping and therefore can be reported to the LMF as different sets/groups (each set comprising of timestamps of one or more measurement instances). |
| Qualcomm | A lot of similarity between 5-1 and 5-3. Lets first agree that there will be a configured measurement window and then we can decide the details. Both 5-1 and 5-3 talk about a specific time-domain measurement window/instance to be used, just there is a different formulation in both. Suggest to merge them. |
| Apple | Support the intention |
| Nokia/NSB | Can a proponent explain how this solves the Tx/Rx timing error problem? |
| SONY | We think MTW is not needed. |
| CMCC | We share similar view as other companies that it seems no need to define and configure the measurement time window. |
| Samsung | No need the MTW for now. |
| LG | We are supportive. Without measurement time window, UE can report the UE Rx-Tx time difference measurement based on the most recent measurement samples, but the gNB can assume the UE which is semi-static, and then it may calculate the average value of the gNB Rx-Tx time difference measurement acquired over a relatively long time duration for the improved measurement accuracy. It leads to an inaccurate RTT measurement at the LMF. Thus, both of the UE and the gNB should follow an aligned rule (within measurement time window) to determine a measurement for reporting of the Rx-Tx time difference and RSTD. |

### Proposal 5-2 (H)

* The timestamps for the measurement instances in a measurement report are defined by one of the following options:
  + Option 1:
    - The timestamp of a UE (or TRP) measurement instance can be any time instance between the reception time of the first and the last DL-PRS resource set(s) (or SRS-Pos resource set(s)) that are used to determining the measurement instance.
  + Option 2:
    - The timestamp of the UE (or TRP) measurement instance corresponds to the reception time of the last DL-PRS resource set (or the last SRS-Pos resource set) that are used to determining the measurement instance.
  + Option 3:
    - Not specify the timestamps for the measurement instances (i.e., up to UE/TRP implementation)

Comments

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| **Company** | **Comments** |
| ZTE | We suggest to add a new option:   * + Option 4:     - The timestamp of the UE (or TRP) measurement instance corresponds to the reception time of the ~~last~~ first DL-PRS resource set (or the ~~last~~ first SRS-Pos resource set) that are used to determining the measurement instance. |
| OPPO | Reuse the same meaning of timestamps in TS 37.355, i.e., timestamp specifies the time instance at which the measurement instance is performed |
| CATT | We support Option1. |
| vivo | Option2 is preferred. |
| Ericsson | We support option 2. Good with a well defined UE/TRP behaviour. The reception time of the last DL-PRS resource set is a bit unclear (e.g. which PRS resource in the set is used for the time stamp?) |
| Huawei, HiSilicon | Support Option 2. |
| Lenovo,Motorola Mobility | Support Option 2, the timestamp should be associated with the last measured DL-PRS resource (to avoid ambiguity mentioned by Ericsson). |
| Nokia/NSB | We are okay with Option 2. Good to have common understanding between LMF and UE/TRP on the timestamp meaning. |
| SONY | Same view as OPPO |
| CMCC | We are OK with Option 2. |
| Samsung | Option 2. |

### Proposal 5-3 (H)

* Each UE measurement instance can be configured by LMF with *N* instances of the DL-PRS Resource Set, where
  + Option 1: N=[1,2, 4, 8,…,256]
    - FFS: the configuration is per measurement report, or per TRP, or per positioning frequency layer
  + Option 2: *N* is decided by RAN4
* Each TRP measurement instance can be configured by LMF with *M* instances of the UL-SRS Resource Set, where
  + Option 1: M=[1,2, 4, 8,…,256]
    - FFS: the configuration is per measurement report, or per TRP, or per positioning frequency layer
  + Option 2: the configuration is decided by RAN4

Comments

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| **Company** | **Comments** |
| ZTE | The FFS should include that N is configured per DL-PRS resource set, because even for a same TRP, different measurement instances may have different instances of its corresponding PRS resource set. Like the figure used in our tdoc(with a little modification), measurement instance 1 contains 3 times of PRS resource set 1, measurement instance 2 contains 2 times of PRS resource set 2.  measurement instance-1 |
| OPPO | It up to RAN4 (i.e., RAN4) as the number is related to the positioning requirement |
| CATT | Support FL proposal. |
| vivo | Support option2.  The relationship between ‘the number of DL-PRS Resources Set instances related to each UE measurement instance’ and ‘the number of PRS samples for RSTD/Rx-Tx time difference/PRS-RSRP measurements’ defined by RAN4’ should be clarified.  In TS38.133, in RSTD measurement requirement, ‘’ is defined as the number of PRS RSTD samples (or instances of DL-PRS Resource Set here) and ‘’= 4. The motivation behind allowing more than one PRS sample in defining the measurement period is to ensure that with channel variations or deep fading, there is at least one PRS sample that satisfies the side conditions. That is, the UE needs to measure 4 PRS samples to get a measurement result. Compared with the requirement of RAN4, RAN1 seems to be more inclined to configure the number of DL-PRS Resource Set instances in a measurement instance flexibly. Therefore, we suggest to ask RAN4 to reach a consensus, and then we can determine the value of N and whether N can be configured by the network. |
| Ericsson | We support Option 1. We understand this as that each measurement instance utilize max N occasions of a DL PRS resource set. Important to be able to configure UE to use only one DL PRS occasion (i.e. not to filter/average) so that timing errors don’t drift during the measurement instance. |
| Huawei, HiSilicon | Support. |
| Lenovo,Motorola Mobility | Support FL’s proposed options for both UE and TRP measurement instances. Options can be further downselected at a later stage. |
| Qualcomm | A lot of similarity between 5-1 and 5-3. Lets first agree that there will be a configured measurement window and then we can decide the details. Both 5-1 and 5-3 talk about a specific time-domain measurement window/instance to be used, just there is a different formulation in both. Suggest to merge them.  For example, if the measurement window is small enough, then there will “N=1” instances inside. Whether we count the window in “instances” or in “start/end” is a detail. |
| Nokia/NSB | Can a proponent explain how this mitigates Rx/Tx timing errors? |
| CMCC | It can be up to RAN4 |
| Samsung | Either option2 or we can discuss further. |
| LG | It is up to RAN4. However, since some companies consider N=1 instance for latency reduction, we are open to inform RAN4 with related information. |

### Proposal 5-4

* Consider the following options for the measurement enhancements:
  + Option 1: multiple measurement instances are associated with the indicated DL PRS resource.
  + Option 2: For each indicated DL PRS resource set in a measurement report, multiple measurement instances are associated with the indicated DL PRS resource set.
  + Option 3: For each indicated measurement element (i.e. TRP) in a measurement report, multiple measurement instances are associated with the indicated measurement element.
  + Option 4: For each indicated positioning method in a measurement report, multiple measurement instances are associated with the indicated positioning method.
  + Option 5: Multiple measurement instances are directly associated with a measurement report.

Comments

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| **Company** | **Comments** |
| ZTE | We prefer option 3. |
| OPPO | More discussion is needed. There are some overlapping between different options. Option 3 is our first preference. |
| CATT | We prefer Option 2. Each UE measurement instance can be configured with N instances of the DL-PRS Resource Set. |
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### Proposal 5-6

* Discuss whether to send an LS to RAN4 for the clarification of the relationship between ‘the number of DL-PRS Resources Set instances related to each UE measurement instance’ and ‘the number of PRS samples for RSTD/Rx-Tx time difference/PRS-RSRP measurements’.

Comments

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| **Company** | **Comments** |
| CATT | Support. According to TS38.133, the UE needs to measure 4 DL-PRS samples to get a RSTD/Rx-Tx time difference/PRS-RSRP measurements. Therefore, we prefer to send an LS to RAN4 for the clarification of the N (instances of the DL-PRS Resource Set). |
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### Proposal 5-5

* Support extending the existing UE timing quality indication to indicate the quality of timing-based measurement instances such as RSTD and UE Rx-Tx time difference measurements.
* FFS if the indication is applicable to one or more measurement instances.

Comments

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| **Company** | **Comments** |
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# Additional proposals

## Configure an SRS with a spatial relation towards a DL PRS or SSB

Submitted Proposals

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 8 It shall be possible to configure an SRS with a spatial relation towards a DL PRS or SSB together with a configuration to utilize a certain UE TX TEG.

FL comments

For the estimation UE TX timing error difference, it was proposed in [19] to configure an SRS with a spatial relation towards a DL PRS or SSB together with a certain delay group, in order to support the UE to transmit each SRS towards TRPs with each delay group (i.e., antenna panel). A similar proposal was discussed in RAN#104e without a conclusion. Suggest further discuss the proposed enhancement, including the potential benefits and implementation issues.

### Proposal 6.1-1

* Support to configure an SRS with a spatial relation towards a DL PRS or SSB together with a configuration to utilize a certain UE TX TEG

Comments

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| **Company** | **Comments** |
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## Beam and delay group sweeping

Submitted Proposals

* (Ericsson, [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc)[19]) Proposal 9 Support SRS with beam and UE TX TEG sweeping.

FL Comments

In [19], beam and UE TX TEG sweeping is supported for the SRS to reduce positioning overhead for multi antenna panel SRS transmission scheme.

### Proposal 6.2-1

* Study whether and how to support beam and UE TX TEG sweeping for the transmission of the UL Positionig SRS.

Comments

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| **Company** | **Comments** |
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# LS To/From other WGs

## Reply LS SA2 (R1-2102306)

Background

In the LS from SA2 (R1-2102306), SA2 asks RAN1 and RAN2 whether support can be provided for a scheduled location time as part of Rel-17 and as defined in the attached CR to TS 23.273.

Submitted Proposals

* (Qualcomm, [R1-2104671](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104671.doc)[6]) Proposal 9: Send a draft Reply LS:
  + RAN1 thanks SA2 for their LS on Scheduling Location in Advance to reduce Latency.
  + RAN1 discussed the subject matter and agrees that scheduling location in advance is within the positioning enhancement work item objective, and RAN1 will target supporting this feature in Rel-17 positioning enhancement time frame in alignment with the CR received from SA2.
* (Qualcomm, [R1-2104671](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104671.doc)[6]) Proposal 10: Send a draft Reply LS:
  + For UE-based positioning, a UE is expected to report a location estimate which is valid for the requested “Location Time”.

FL comments

The proposals can be discussed in the email thread for the reply LS to SA2.

Comments

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| **Company** | **Comments** |
| OPPO | Where is the attached CR? I don’t find the attached CR in the LS |
| Nokia/NSB | Agree with FL comments. |
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# References

1. [R1-2104277](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104277.doc) Enhancement to mitigate gNB and UE Rx/Tx timing error Huawei, HiSilicon
2. [R1-2104359](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104359.doc) Discussion on potential enhancements for RX/TX timing delay mitigating vivo
3. [R1-2104520](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104520.doc) Discussion on accuracy improvements by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays CATT
4. [R1-2104590](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104590.doc) Positioning accuracy improvement by mitigating timing delay ZTE
5. [R1-2104611](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104611.doc) Discussion on mitigation of gNB/UE Rx/Tx timing errors CMCC
6. [R1-2104671](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104671.doc) Enhancements on Timing Error Mitigations for improved Accuracy Qualcomm Incorporated
7. [R1-2104739](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104739.doc) Enhancement of timing-based positioning by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays OPPO
8. [R1-2104871](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104871.doc) Discussion on accuracy improvements by mitigating timing delays InterDigital, Inc.
9. [R1-2104905](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2104905.doc) Mitigation of UE/gNB TX/RX Timing Errors Intel Corporation
10. [R1-2105105](E:\\1 Meetings\\RAN1\\Docs\\R1-2105105.doc) Positioning accuracy enhancements under timing errors Apple
11. [R1-2105168](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105168.doc) Discussion on mitigating UE Rx/Tx and gNB Rx/Tx timing delays Sony
12. [R1-2105310](E:\\1 Meetings\\RAN1\\Docs\\R1-2105310.doc) Discussion on accuracy improvements by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays Samsung
13. [R1-2105482](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105482.doc) Discussion on accuracy improvement by mitigating UE Rx/Tx and gNB Rx/Tx timing delays LG Electronics
14. [R1-2105512](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105512.doc) Views on mitigating UE and gNB Rx/Tx timing errors Nokia, Nokia Shanghai Bell
15. [R1-2105699](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105699.doc) Discussion on mitigating UE and gNB Rx/Tx timing delays NTT DOCOMO, INC.
16. [R1-2105759](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105759.doc) Mitigation of RX/TX timing delays for higher accuracy MediaTek Inc.
17. [R1-2105856](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105856.doc) On methods for Rx/Tx timing delays mitigation Fraunhofer IIS, Fraunhofer HHI
18. [R1-2105859](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105859.doc) Enhancements for mitigation of Tx/Rx Delays Lenovo, Motorola Mobility
19. [R1-2105908](file:///E:\\1%20Meetings\\RAN1\\Docs\\R1-2105908.doc) Techniques mitigating Rx/Tx timing delays Ericsson
20. RP-202900, “New WID on NR Positioning Enhancements”, CATT, Intel Corporation, Ericsson, December 7th – 11th, 2020.
21. R1- 2103992, FL Summary #4 for accuracy improvements by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays, Moderator (CATT)
22. R1-2105937 Discussion on scheduling location in advance to reduce latency Huawei, HiSilicon
23. R1-2104167 Response LS on Scheduling Location in Advance to reduce Latency RAN2, Qualcomm