**3GPP TSG RAN WG1 Meeting #104bis-e** [**R1-2103781**](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103781.doc)

**e-meeting, April 12th– 20th, 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:

[104b-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 Apr-15, Apr-20 – 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 [1-22]:

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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 Rx/Tx timing errors in DL+UL positioning
	4. gNB Rx/Tx timing errors for 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
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**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.
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Submitted proposals

In the meeting, there are further discussions related to the above definitions:

* (Huawei [R1-2102348](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102348.doc)) Proposal 6: Extend the UE Tx TEG to be port specific, and extend the gNB measurement indication associated with SRS port.
* (OPPO [R1-2102399](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102399.doc)[3]) Proposal 1: RAN1 sends a LS to inform RAN4 the definition of UE Tx TEG, TRP Tx TEG, UE Rx TEG, TRP Rx TEG, UE RxTx TEG, TRP RxTx TEG, and to ask for the answers of the following questions:
	+ Q1: What’s the typical value of the certain margin for each definition?
	+ Q2: Whether or not can UE measure the timing error with sufficient accuracy?
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])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.
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])Proposal 2:
	+ Support 1 Tx TEG and 1 Rx TEG on the TRP side for positioning, so that a TRP does not need to provide the association information with Rx/Tx TEG to the LMF.
* (Samsung [R1-2103243](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103243.doc)[14])Proposal 2: RAN1 further considers TEG with the two following options:
	+ Option1: The TEG can be defined to indicate antenna panel index, i.e., two measurements associated with the same TEG means that these measurements are obtained at the same antenna panel.
	+ Option2: The TEG index can be supported as an indicator for the value range of RX/TX timing errors associated reported measurement.
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-1: Using TEG to implicitly indicate the associated physical antenna panel is feasible for gNB side, even though gNB may at the end implement a single antenna panel
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-2: RTD could be TX TEG specific if there are multiple antenna panels at TRPs
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-3: TX group delay difference between a pair of TRPs is part of RTD
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-4: If TRP has multiple antenna panels, each having its own RF chain, then there should be association between DL-PRS transmission and physical antenna panel (represented by TX TEG implicitly)
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-9: For the TRP with on-the-fly inside-chip calibration capability, the estimated round-trip group delay and corresponding statistics per physical antenna panel could report to the location server to facilite downlink RTD estimation
* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 1 Two UL SRS transmissions should be classified as being part of the same UE TX TEG only if the maximum difference in timing error between the two UL SRS transmissions is evaluated by the UE to be smaller than some threshold value.
* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 5 Two TOA measurements should be classified as being part of the same UE RX TEG only if the maximum difference in timing error between the two TOA measurements is evaluated by the UE to be smaller than some threshold value.
* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 17 Reporting of gNB RX/TX TEG associations should not be specified since alternative mitigation techniques based on Rel. 16 exist.

FL comments

* For Huawei’s proposal to extend the UE Tx TEG to be port specific, and extend the gNB measurement indication associated with SRS port, SRS for positioning is currently transmitted only from a single port. It might be reasonable to extend to the port if SRS for positioning is transmitted in more than one port, or when the UE Tx TEG and TRP Rx TEG are associated with the ports of SRS;
* For OPPO’s suggestion to send an LS to inform RAN4 on the definition of UE Tx TEG, TRP Tx TEG, UE Rx TEG, TRP Rx TEG, UE RxTx TEG, TRP RxTx TEG, a similar proposal was discussed in RAN1#104e. At that time, it was considered too early to send the LS. We may further discuss whether to send LS to RAN4 together with other progress in RAN1 after RAN1 decides to introduce the TEGs.
* For vivo’s suggestion to clarify the “inter-TRP timing errors” on whether to include synchronization error between TRPs, and MTK’s proposal that “RTD could be TX TEG specific if there are multiple antenna panels at TRPs” and “TX group delay difference between a pair of TRPs is part of RTD”, and reporting “the estimated round-trip group delay and corresponding statistics per physical antenna panel” for downlink RTD estimation, my understanding is the enhancements purely for the purpose of network synchronization is not within the scope of this WI. However, the WI does not exclude the enhancements for mitigating UE/TRP Tx/Rx that may also have the side benefits of mitigating the impact of the network synchronization errors;
* For Samsung’s suggestion that “The TEG can be defined to indicate antenna panel index” and MediaTek’s “Using TEG to implicitly indicate the associated physical antenna panel is feasible for gNB side”, my understanding is that one TEG may include one or more physical antenna panels, which depends on the value range of RX/TX timing errors, and the error margin threshold.
* For Samsung’s suggestion that “The TEG index can be supported as an indicator for the value range of RX/TX timing errors associated reported measurement” and Ericsson’s proposal to use some threshold value for the clarification of the TEGs, I assume that is something RAN1 needs further discussion.

We may further work on the details of the proposals related to the details on the configurations and the associations of the UE/TRP Rx/Tx TEGs after RAN1 concludes to introduce the concept of the TEGs into the specification.

### Proposal 2-1

* Extend the UE Tx TEG and the TRP Rx TEG be associated with the SRS port.

Comments

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| **Company** | **Comments**  |
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### Proposal 2-2

* RAN1 sends an LS to inform RAN4 of the definition of UE Tx TEG, TRP Tx TEG, UE Rx TEG, TRP Rx TEG, UE RxTx TEG, TRP RxTx TEG, and to ask for the answers to the following questions:
	+ Q1: What’s the typical value of the certain margin for each definition?
	+ Q2: Whether or not can UE measure the timing error with sufficient accuracy?

Comments

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| **Company** | **Comments**  |
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### Proposal 2-3

* Support only 1 Tx TEG and 1 Rx TEG per CC for TRP
	+ Note: In this case, there is no need to specify the TRP RX/TX TEG associations.

Comments

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| **Company** | **Comments**  |
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### Proposal 2-4

* Two transmissions should be classified as the same Tx TEG only if the transmitter determines the maximum difference in timing error between the two transmissions is smaller than a threshold value.
	+ FFS: how the threshold value for Tx TEG is defined/configured
	+ FFS: whether the transmitter is a UE, a TRP, or both
* Two measurements should be classified as the same RX TEG only if the receiver determines the maximum difference in timing error between the two measurements is smaller than a threshold value.
	+ FFS: how the threshold value for Tx TEG is defined/configured
	+ FFS: whether the receiver is a UE, a TRP, or both

Comments

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| **Company** | **Comments**  |
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# Methods for mitigating UE/TRP Tx/Rx timing errors

Background

In RAN1#104e, RAN1 reached the conclusions on the options to be studied for mitigating TRP Tx timing errors and/or UE Rx timing errors for DL TDOA, UL TDOA and DL+UL positioning. There are a significant number of options to be studied. In this meeting, we are targeting to decide on which of the options should be supported in Rel-17.

Submitted Proposals (maybe for all positioning solutions)

* (ZTE [R1-2102668](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102668.doc)[6]) Proposal 1: Support to indicate TEG information or identification in the configuration or report for multi-RTT, DL-TDOA and UL-TDOA method
* CMCC [R1-2102886](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102886.doc)[8]) Proposal 5: Support signalling enhancements to allow the LMF to deliver the timing errors to UEs using UE-based positioning
* (InterDigital [R1-2103005](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103005.doc) [10]) Proposal 7: Study conditions under which the Tx/Rx timing errors may be sent from the LMF to the UE
* (Intel [R1-2103035](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103035.doc)[11])Proposal 5:Support introduction of gNB/TRP TX TEG ID associated with the DL PRS Resource ID (or multiple IDs) and/or DL PRS Resource Set ID (or multiple IDs)
* (Intel [R1-2103035](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103035.doc)[11])Proposal 6: Support introduction of UE TX TEG ID associated with the SRS Resource ID (or multiple IDs) and/or SRS Resource Set ID (or multiple IDs)
	+ (Intel [R1-2103035](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103035.doc)[11])Proposal 4: Support TX/RX timing errors measurement report signaling from gNB/TRP to LMF and/or reference device to LMF, including the following information/measurements:
	+ For the DL-TDOA positioning method, report time difference value (RSTD) (*ti*-*RDli*,*n* – *tj*-*RDlj*,*n*) between the *i*th gNB/TRP with the *li*th TX TEG and the reference device with the *n*th RX TEG and the *j*th gNB/TRP with the *lj*th TX TEG and the reference device with the *n*th RX TEG
	+ For the UL-TDOA positioning method, report time difference value (RTOA) (*tRD*-*im*,*ki* – *tRD*-*jm*,*kj*) between the reference device with the *m*th TX TEG and the *i*th gNB/TRP with the *ki*th RX TEG and the reference device with the *m*th TX TEG and the *j*th gNB/TRP with the *kj*th RX TEG
	+ For the Multi-RTT positioning method, report RX-TX time difference for the *i*th gNB with the *li*th TX TEG and the *ki*th RX TEG and the RX-TX time difference for the reference device with the *m*th TX TEG and the *n*th RX TEG
	+ (Intel [R1-2103035](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103035.doc)[11])Proposal 8: Support TX/RX timing errors measurement report signaling from gNB/TRP to LMF and/or UE to LMF, including the following information/measurements:
	+ For the DL-TDOA positioning method, report time difference value (*ti*-*UEli*,*ni* – *ti*-*UEli*,*nj*) between the *i*th gNB/TRP with the *li*th TX TEG and the UE with the *ni*th RX TEG and the *i*th gNB/TRP with the *li*th TX TEG and the UE with the *nj*th RX TEG
	+ For the UL-TDOA positioning method, report time difference value (*tUE*-*imi*,*ki* – *tUE*-*imj*,*ki*) between the UE with the *mi*th TX TEG and the *i*th gNB/TRP with the *ki*th RX TEG and the UE with the *mj*th TX TEG and the *i*th gNB/TRP with the *ki*th RX TEG
	+ For the Multi-RTT positioning method, report RX-TX time difference for the *i*th gNB with the *li*th TX TEG and the *ki*th RX TEG and the RX-TX time difference for the UE with the *mi*th TX TEG and the *ni*th RX TEG
* (Apple [R1-2103109](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103109.doc)[12])Proposal 1: 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
* (Qualcomm [R1-2103170](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103170.doc)[13])Proposal 1: Support the following enhancements with regards to TEG Information Reporting:
	+ A device (UE or gNB) may provide to the entity performing the positioning calculation (UE or LMF) the following
		- An associated Rx or RxTx TEG ID for each performed positioning measurement, depending on the measurement type
		- Rx-TEG for RSTD/RTOA and RxTx-TEG for Rx-Tx measurement
		- An associated Tx TEG ID for a transmitted Reference Signal Resource (SRS or DL-PRS)
		- Information on the time error difference amongst the provided TEG IDs (e.g. mean/uncertainty of the timing error differences).
	+ With regards to the method-specific conclusions reached in the previous meeting, the above proposal corresponds to the following:
		- DL-TDOA: Options 1, 2, 8, 9, 10
		- UL-TDOA: Options 1, 2, 4
		- DL/UL UE-side: Options 4, 7
		- DL/UL gNB-side: Options 4, 6
* (CEWiT [R1-2103682](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103682.doc)[21])Proposal 3: In DL-TDOA, UE should report the RSTD measurements along with associated TEG ID to LMF. In ULL-TDOA, gNB/TRP should report the RTOA measurements along with associated TEG ID to LMF.
* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 2 Specify signaling from the UE to the network of which UE TX TEG is associated with each SRS-transmission from the UE.
* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 6 Include indication of UE RX TEG used for the DL PRS reception and the corresponding TOA measurement both for the reference TRP and for the target TRP in the DL RSTD measurement report.
* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 7 Specify multi UE RX TEG RSTD measurements and the corresponding configuration and measurement reporting signalling.
* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 8 RAN1 should study further under what circumstances the UE should be capable to perform multi delay group RSTD measurements, e.g. if multi UE RX TEG RSTD measurements can be performed using 1) different symbols of the same DL PRS, 2) different repetitions of the same DL PRS, 3) different occasions of the same DL PRS, 4) different DL PRSs transmitted from the same TRP, and/or 5) simultaneous reception of the same DL PRS.
* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 18 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.
* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 19 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.

Submitted Proposals (specific for DL positioning)

* (Huawei [R1-2102348](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102348.doc)) Proposal 3: Support the following Options for DL-TDOA
	+ Option 1:
		- Support a TRP to provide the association information of DL PRS resources with Tx TEGs to LMF
		- This should target TRPs deployed across multiple CCs
	+ 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
	+ Note: Option 9 is already supported in the current LPP, with different positioning frequency layers from a TRP having its own RTD.
* (BUPT [R1-2102364](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102364.doc)[2]) Proposal 2: For DL TDOA method, the transfer of Tx timing delays of TRPs from NR-RAN node to LMF via NRPPa.
* (BUPT [R1-2102364](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102364.doc)[2]) Proposal 3: For UE-based DL-TDOA method, the signaling of the Tx timing delays of TRPs from LMF to UE via LPP
* (OPPO [R1-2102399](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102399.doc)) Proposal 2: For the mitigation of gNB Tx and UE Rx timing error for DL TDOA
	+ Option3,4,6,7,8,9,10 are not considered further.
	+ RAN4 should be involved to ensure the feasibility of Option 1,2,5
* (OPPO [R1-2102399](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102399.doc)) Proposal 3: If Option 1 is supported for DL TDOA positioning, Rel-17 supports the transfer of the association information of DL PRS resources with Tx TEGs from NR-RAN node to LMF via NRPPa.
* (OPPO [R1-2102399](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102399.doc)) Proposal 4: If Option 1 and 2 are supported for UE-based DL-TDOA method, Rel-17 supports the signaling of the association information of DL PRS resources with Tx TEGs from LMF to UE via LPP.
* (OPPO [R1-2102399](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102399.doc)) Proposal 5: If Option 5 is supported for DL TDOA positioning, Rel-17 supports the transfer of the association information of RSTD measurements with one or more reference TRP(s) from UE to LMF via LPP
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])Proposal 3:
	+ The UE can be requested to provide the association information of RSTD measurements with UE Rx TEG(s) to LMF when the UE supports more than 1 UE Rx TEG
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])Proposal 4:
	+ 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.
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])Proposal 5:
	+ 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.
* (CATT [R1-2102635](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102635.doc)[5]) Proposal 12: For UE-assisted DL-TDOA positioning, all of the following three methods should be supported to help LMF eliminate the influence of timing errors of TRPs and UE:
	+ Method1: Provide LMF the association information of DL PRS resources or RSTD measurements with Tx or Rx TEGs.

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| **DL-TDOA** | **From** | **To** | **Signalling for mitigating TRP Tx and UE Rx timing errors** |
| Option 1 | TRP | LMF | Association information of DL PRS resources with Tx TEGs |
| Option 5 | UE | LMF | Association information of RSTD measurements with UE Rx TEG(s) |

* + Method2: Provide LMF 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 |

* + Method3: Provide LMF 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 |

* (CATT [R1-2102635](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102635.doc)[5]) Proposal 13: For UE-based DL-TDOA positioning, all of the following three methods should be supported to help UE eliminate the influence of timing errors of TRPs:
	+ Method1: Provide UE the association information of DL PRS resources with Tx TEGs.

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| **DL-TDOA** | **From** | **To** | **Signalling for mitigating TRP Tx timing errors** |
| Option 2 | LMF | UE | Association information of DL PRS resources with Tx TEGs  |

* + Method2: Provide UE 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 |

* + Method3: Provide UE 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 |

* (ZTE [R1-2102668](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102668.doc)[6]) Proposal 2: For DL-TDOA, support option 5 for mitigating UE Rx timing errors, and one of the following alternatives should be supported:
	+ Alt 1: In a measurement report, both neighbor TRP and reference TRP will be associated with corresponding UE Rx TEG ID, which indicates the UE Rx TEG used for determining timing of the TRPs.
	+ Alt 2: UE reports a parameter along with each RSTD measurement to indicate whether the RSTD measurement contains the Rx timing error or not. If the parameter is 0, this RSTD measurement is not perturbed with UE Rx timing error; if the parameter is 1, this RSTD measurement is perturbed with UE Rx timing error.
* (ZTE [R1-2102668](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102668.doc)[6]) Proposal 3: For DL-TDOA, support UE to report multiple reference timing with respect to multiple UE Rx TEGs.
* (ZTE [R1-2102668](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102668.doc)[6]) Proposal 4: For DL-TDOA, support TRP to provide the information to LMF that indicates whether the Tx timing errors of DL PRS resources have been calibrated/pre-compensated locally within a certain margin.
* (China Telecom [R1-2102869](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102869.doc)[7]) Proposal 1-1: Support a TRP to provide the association information of DL PRS resources with Tx TEGs to LMF.
* (China Telecom [R1-2102869](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102869.doc)[7]) Proposal 1-2: Support LMF to provide the association information of DL PRS resources with Tx TEGs to UE for UE-based positioning.
* (China Telecom [R1-2102869](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102869.doc)[7]) Proposal 1-3: 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.
* (China Telecom [R1-2102869](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102869.doc)[7]) Proposal 1-4: Support LMF to provide Rx timing errors per Rx TEG to a UE for UE-based positioning.
* (China Telecom [R1-2102869](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102869.doc)[7]) Proposal 1-5: Support a UE to provide Rx timing errors per Rx TEG to LMF for UE-assisted positioning.
* (China Telecom [R1-2102869](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102869.doc)[7]) Proposal 2: The Tx timing errors should be pre-compensate/calibrate at the Tx side instead of reporting to LMF.
* (CMCC [R1-2102886](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102886.doc)[8]) Proposal 6: Support 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 3 (if available): Support a TRP to provide the Tx timing errors per Tx TEG to LMF
	+ 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 11: Support a reference device using UE-based positioning to provide the Tx timing error differences between Tx TEGs of different TRPs to the LMF
* (Nokia [R1-2103002](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103002.doc)[9])Proposal 4: RAN1/RAN4 should consider the feasibility of Option 3,4,6, and 7.
* (Nokia [R1-2103002](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103002.doc)[9])Proposal 5: Consider option 8b for DL-TDOA, which is support a reference UE to provide the Tx timing error difference between Tx TEGs to LMF.
* (Nokia [R1-2103002](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103002.doc)[9])Proposal 6: Prioritize studying Options 1, 2, 5, 8b, 9, and 10 for DL-TDOA.
* (InterDigital [R1-2103005](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103005.doc) [10]) Proposal 5: Support the following options for DL-TDOA to correct Tx/Rx errors
	+ Option 2: Support LMF to provide the association information of DL PRS resources with Tx TEGs to UE for UE-based positioning
	+ Option 4: Support LMF to provide the Tx timing errors per Tx TEG of TRP to a UE for UE-based positioning
	+ Option 6: Support LMF to provide Rx timing errors per Rx TEG to a UE for UE-based positioning
	+ Option 9: Support LMF to provide the Tx timing error differences between Tx TEGs of a TRP to a UE for UE-based positioning
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-11: For DL-RSTD measurement, UE may also report whether the respective TOF measurement for forming a DL-RSTD measurement is through different antenna panel (RX TEG) for receiving
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-12: For DL-RSTD measurement, the statistics (variance) of RX group delay difference at UE which are related to different frequency layers for receiving, and different antenna panels for receiving may report to the location server
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4c-1: To facilitate the on-the-fly downlink and uplink RTD estimation, the location server may request the gNBs to meet the association of a same antenna panel for DL-PRS transmission and SRS receiving

Submitted Proposals (specific for UL positioning)

* (Huawei [R1-2102348](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102348.doc)[1]) Proposal 2: Support the following Options 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.
		- This should target TRPs deployed across multiple CCs.
	+ Option 2b (updated from Option 2):
		- Support a UE to provide the association information of SRS resources/ports used for positioning with UE Tx TEG(s) to LMF for UL TDOA positioning.
	+ Option 2c:
		- Support a TRP to provide the association information of RTOA measurements with SRS resources/SRS ports to LMF when the TRP reports the RTOA measurements.
	+ Option 4b (updated from Option 4):
		- Support a UE to provide the statistics (variance, bound, etc.) of the Tx timing error differences between Tx TEGs to LMF for UL TDOA positioning.
* (OPPO [R1-2102399](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102399.doc)[3]) Proposal 6: For the mitigation of UE Tx timing error for UL TDOA,
	+ Option 3 and 4 are not considered further.
	+ RAN4 should be involved to ensure the feasibility of Option 1 and 2
* (OPPO [R1-2102399](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102399.doc)[3]) Proposal 7:
	+ If Option 1 is supported for NR UL RTOA based positioning, Rel-17 supports the transfer of the association information of RTOA measurements with Rx TEGs from NR-RAN node to LMF via NRPPa.
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])Proposal 6:
	+ The UE can be requested to provide the association information of SRS resources for positioning with UE Tx TEG(s) to LMF when the UE supports more than 1 UE Tx TEG.
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])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.
	+ FFS how to provide this information to the LMF by the UE.
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])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 gNB performing SRS measurements, to prevent the gNB performing joint processing on different SRS measurement time occasions associated with different UE Tx TEGs for the same SRS resource(s).
	+ FFS how to provide this information to the gNB performing SRS measurements.
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])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).
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])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 with different UE Tx TEGs.
	+ FFS the gNB reporting rules to guarantee the RTOA measurement report for more than one UE Tx TEG(s).
* (CATT [R1-2102635](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102635.doc)[5]) Proposal 14: For UL-TDOA positioning, all of the following three methods should be supported to help LMF eliminate the influence of timing error of TRPs and UE:
	+ Method1: Provide LMF the association information of RTOA measurements or SRS resources for positioning with Rx or Tx TEGs

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| **UL-TDOA** | **From** | **To** | **Signalling for mitigating UE Tx timing errors** |
| Option 1 | TRP | LMF | Association information of RTOA measurements with Rx TEGs  |
| Option 2 | UE | LMF | Association information of SRS resources for positioning with UE Tx TEG(s) |

* + Method2: Provide LMF 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 |

* + Method3: Provide LMF 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 |

* (ZTE [R1-2102668](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102668.doc)[6]) Proposal 5: For UL-TDOA method, support TRP to report RTOA measurement with the associated SRS resource ID/SRS resource set ID.
* (ZTE [R1-2102668](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102668.doc)[6]) Proposal 6: For UL-TDOA, support TRP to provide the information to LMF that indicates whether the Rx timing errors of UL SRS resources have been calibrated/pre-compensated locally within a certain margin.
* (China Telecom [R1-2102869](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102869.doc)[7]) Proposal 3: Support a UE to provide the association information of SRS resources for positioning with UE Tx TEG(s) to LMF for UL TDOA positioning.
* (CMCC [R1-2102886](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102886.doc)[8]) Proposal 7: Support the following options 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 (if available): Support a UE to provide Tx timing errors per Tx TEG to LMF for UL TDOA positioning
* (Nokia [R1-2103002](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103002.doc)[9])Proposal 7: For UL-TDOA and Multi-RTT prioritize the options that correspond to Options 1, 2, 5, 8b, 9, and 10 in DL-TDOA.
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4b-1: The association between SRS transmission and the physical antenna panel (TX TEG) may provide to the location server
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4b-2: The estimated round-trip group delay and corresponding statistics at TRPs may also report to the location server to facilitate uplink RTD estimation for UL-TDOA technique

Submitted Proposals (specific for DL+UL positioning)

* (Huawei [R1-2102348](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102348.doc)[1]) Proposal 4: Support UE RxTx TEG information for UE Rx – Tx time difference measurement.
	+ The SRS transmission associated with a UE Tx TEG should be received by the TRP that transmits the PRS that is received by the UE Rx TEG paired with the UE Rx TEG in the same UE RxTx TEG.
* (Huawei [R1-2102348](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102348.doc)[1]) Proposal 5: Support TRP RxTx TEG information for gNB Rx – Tx time difference measurement when SRS are received from multiple CCs
* (OPPO [R1-2102399](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102399.doc)) Proposal 8: For mitigating UE Rx/Tx timing errors in DL+UL positioning
	+ Option 6, 7 are not considered further.
	+ RAN4 should be involved to ensure the feasibility of Option 1, 2, 3, 4 and 5
* (OPPO [R1-2102399](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102399.doc)[3]) Proposal 9: For mitigating gNB Rx/Tx timing errors in DL+UL positioning,
	+ Option 5 and 6 are not considered further
	+ RAN4 should be involved to ensure the feasibility of Option 1, 2, 3 and 4
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])Proposal 11:
	+ In DL and UL positioning, support the UE to provide the association information of UE Rx-Tx time difference measurements with UE Rx TEGs in the measurement report to LMF.
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])Proposal 12:
	+ In DL and UL positioning, support the UE to provide additional information of UE ‘Rx timing error+Tx timing error’ associated with some combinations of Rx TEGs and Tx TEGs to the LMF.
	+ e.g., when Rx TEGs and Tx TEGs are combined, if the ‘Rx timing error+Tx timing error’ of some combinations is within a certain margin, the UE provides this information to the LMF.
* (CATT [R1-2102635](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102635.doc)[5]) Proposal 15: For DL+UL positioning methods, the following method1 should be supported to help LMF eliminate the influence of timing error of UE:
	+ Method1: Provide LMF the association information of UE Rx-Tx time difference measurements with UE Rx/ Tx TEGs in a measurement report.

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| **DL+UL UE** | **From** | **To** | **Signalling for mitigating UE Rx/Tx timing errors** |
| Option 3 | UE | LMF | Combination of Option 1 and Option 2 |

* (CATT [R1-2102635](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102635.doc)[5]) Proposal 16: For DL+UL positioning methods, the following method1 should be supported to help LMF eliminate the influence of timing error of TRPs:
	+ Method1: Provide LMF the association information of gNB Rx-Tx time difference measurements with TRP Rx/Tx TEGs in a measurement report.

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| **DL+UL TRP** | **From** | **To** | **Signalling for mitigating gNB Rx/Tx timing errors** |
| Option 3 | TRP | LMF | Combination of Option 1 and Option 2 |

* (ZTE [R1-2102668](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102668.doc)[6]) Proposal 7: For DL+UL positioning, support option 1, 2 and 3 at UE side.
	+ For option 1, support UE to report a UE Rx TEG ID to indicate which Rx TEG the related Rx-Tx time difference measurement belongs to.
	+ For option 2, support the following reporting:
		- The UE Tx TEG ID is associated with each Rx-Tx time difference measurement.
		- UE reports SRS resource ID or SRS resource set ID along with the Rx-Tx time difference measurements.
* (ZTE [R1-2102668](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102668.doc)[6]) Proposal 8: For DL+UL positioning at TRP side, support TRP to provide the information to LMF that indicates whether the Rx timing errors of UL SRS resources and Tx timing errors of DL PRS resources have been calibrated/pre-compensated locally within a certain margin.
* (China Telecom [R1-2102869](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102869.doc)[7]) Proposal 4: Support device to provide the association information of UE/gNb Rx-Tx time difference measurements with UE/TRP Rx TEGs in the measurement report to LMF.
* (CMCC [R1-2102886](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102886.doc)[8]) Proposal 8: Support the following options for mitigating UE Rx/Tx timing errors in DL+UL positioning:
	+ Option 3: Combination of Option 1 and Option 2
	+ Option 8: Support a reference device using UE-based positioning to provide the Tx and Rx timing error differences of Tx and Rx TEGs between different TRPs to the LMF
* (CMCC [R1-2102886](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102886.doc)[8]) Proposal 9: Support the following options for mitigating gNB Rx/Tx timing errors in DL+UL positioning:
	+ Option 3: Combination of Option 1 and Option 2
	+ Option 8: Support a reference device using UE-based positioning to provide the Tx and Rx timing error differences of Tx and Rx TEGs between different TRPs to the LMF
* (Nokia [R1-2103002](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103002.doc)[9])Proposal 7: For UL-TDOA and Multi-RTT prioritize the options that correspond to Options 1, 2, 5, 8b, 9, and 10 in DL-TDOA.
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-9: For the TRP with on-the-fly inside-chip calibration capability, the estimated round-trip group delay and corresponding statistics per physical antenna panel could report to the location server to facilite downlink RTD estimation
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-10: To report the estimated round-trip group delay, using “RX TEG+TX TEG” with a unified group index coule be feasible
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4d-2: For M-RTT, in order to do the proper pairing for cancellation, UE may also report using which TX antenna panel for SRS transmission, and gNBs may also need to report using which TX antenna panel for DL-PRS transmission. The terminology of TX TEG could be used
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4d-3: For M-RTT, UE and gNB may report the statistics (variance, uncertainty level) of the round-trip group delay of the associated antenna panel. Round-trip group delay compensation should have been done before reporting.
* (LG [R1-2103621](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103621.doc)[19])Proposal #1: For timing measurement with different Rx/Tx TEGs, following parameter for measurement report and/or assumption for measurement can be specified
	+ TEG ID or value (e.g. timing margin or offset) in measurement report
	+ Ensuring same Rx/Tx TEGs at both UE and TRP within the measurement time window
* (Fraunhofer [R1-2103681](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103681.doc)[20])Proposal 2: For mitigating UE Rx/Tx timing errors in DL+UL positioning methods consider the impact internal UE clock accuracy and drift for:
	+ RxTx timing errors per RxTx TEG
	+ Tx timing errors per Tx TEG

## 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.

|  |
| --- |
| Conclusion: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.
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FL Comments

The following table provides a summary of the opinions on the above options for the mitigation of TRP Tx and UE Rx timing errors for DL TDOA [1-22].

Table 1 Summary of the opinions on the options for mitigating of TRP Tx and UE Rx timing errors for DL TDOA

|  |  |
| --- | --- |
| **Options** | **Opinions from the companies** |
| **Support** | **Not support** | **Additional comments** |
| Option 1: Support a TRP to provide the association information of DL PRS resources with Tx TEGs to LMF | Huawei (for multiple CCs), CATT, China Telecom, CMCC, ZTE, Intel, Nokia, Qualcomm |  | OPPO(need to check feasibility) |
| Option 2: Support LMF to provide the association information of DL PRS resources with Tx TEGs to UE for UE-based positioning | CATT, China Telecom, CMCC, Intel, Nokia, ZTE, InterDigital, Qualcomm |  | OPPO(need to check feasibility) |
| Option 3: Support a TRP to provide the Tx timing errors per Tx TEG to LMF | BUPT, CATT, CMCC(if available) | OPPO, China Telecom, Ericsson | Nokia(need to check feasibility) |
| Option 4: Support LMF to provide the Tx timing errors per Tx TEG of TRP to a UE for UE-based positioning  | BUPT, CATT, CMCC, InterDigital  | OPPO, Ericsson | Nokia(need to check feasibility), InterDigital (need to check feasibility) |
| 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 | Huawei, vivo, CATT, ZTE, China Telecom, CMCC, ZTE, Intel, Nokia, MediaTek, CEWiT, Ericsson,  |  | OPPO(need to check feasibility) |
| Option 6: Support LMF to provide Rx timing errors per Rx TEG to a UE for UE-based positioning | China Telecom, InterDigital, Apple  | OPPO, Ericsson | Nokia(need to check feasibility), InterDigital (need to check feasibility) |
| Option 7:Support a UE to provide Rx timing errors per Rx TEG to LMF for UE-assisted positioning | China Telecom, Intel | OPPO, Ericsson | Nokia(need to check feasibility) |
| Option 8: Support a TRP to provide the Tx timing error differences between Tx TEGs of the TRP to LMF  | CATT, Intel, Qualcomm | OPPO, Ericsson |  |
| Option 9: Support LMF to provide the Tx timing error differences between Tx TEGs of a TRP to a UE for UE-based positioning | CATT, Nokia, InterDigital, Apple , Qualcomm | OPPO, Ericsson | Huawei(already supported in LPP) |
| Option10: Support a UE to provide Rx timing error differences between Rx TEGs to LMF for UE-assisted positioning | Intel, Nokia, Qualcomm | OPPO, Ericsson |  |

**Additional proposals from the contributions:**

* In [4], it was proposed to 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
* In [4].it was proposed that 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
* In [6], two alternatives was proposed for Option 5:
	+ Alt 1: In a measurement report, both neighbor TRP and reference TRP will be associated with corresponding UE Rx TEG ID, which indicates the UE Rx TEG used for determining the timing of the TRPs.
	+ Alt 2: UE reports a parameter along with each RSTD measurement to indicate whether the RSTD measurement contains the Rx timing error or not. If the parameter is 0, this RSTD measurement is not perturbed with UE Rx timing error; if the parameter is 1, this RSTD measurement is perturbed with UE Rx timing error.
* In [6], it was proposed to support UE to report multiple reference timing with respect to multiple UE Rx TEGs for DL-TDOA,
* In [6], it was proposed to support TRP to provide the information of whether the Tx timing errors of DL PRS resources have been calibrated/pre-compensated locally within a certain margin to LMF
* In [7], it was proposed that the Tx timing errors should be pre-compensate/calibrate at the Tx side.
* In [8], it was proposed to support a reference device using UE-based positioning to provide the Tx timing error differences between Tx TEGs of different TRPs to the LMF
* In [9], it was proposed to support a reference UE to provide the Tx timing error difference between Tx TEGs to LMF.
* In [18], it was proposed that the statistics (variance) of RX group delay difference at UE which are related to different frequency layers for receiving, and different antenna panels for receiving may be reported to LMF
* In [18], it was proposed the LMF may request the gNBs to meet the association of the same antenna panel for DL-PRS transmission and SRS receiving to facilitate the on-the-fly downlink and uplink RTD estimation.

FL Comments

Based on the feedback, it seems there is a consensus to support Option 1, 2, and 5 (one company suggested checking the feasibility with RAN4). Thus, it might be better to see if we can have them agreed in the online session (see Proposal 5-1a).

For the remaining options (Options 3, 4, 6-10), there are two or more companies that have concerns. Thus, we may need to have a further discussion in the meeting (see Proposal 3.1-1).

For the additional options proposed from the interested companies in the meeting, we may need to first study them and collect companies’ views to determine which of them should be supported/not supported in el17 in the meeting (see Proposal 3.1-2)

For the proposal of using a reference UE to determine and report the Tx timing error difference between Tx TEGs of to LMF (from [8], [9]]), the proposal is related to the discussion of the reference device for mitigating UE/TRP Rx/Tx timing errors, and also not be limited only to DL TDOA, thus the suggestion is to have a separate proposal for discussion (see Proposal 3.1-3).

### Proposal 3.1-1

* Support 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 the LMF
	+ Option 2:
		- Support the LMF to provide the association information of DL PRS resources with Tx TEGs 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 the LMF when the UE reports the RSTD measurements to the LMF
	+ 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

Comments

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| **Company** | **Comments**  |
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### Proposal 3.1-2

Further study the options 3, 4, 6, 7, 8, 9, and 10 (which was agreed to be studied in RAN1#104e) for mitigating TRP Tx timing errors and/or UE Rx timing errors for DL TDOA, and decide which of them should, or should not, be adapted in Rel-17 in this meeting.

Comments

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| --- | --- | --- |
| **Company** | **Support (Y)/Not Support(N)** | **Additional comments** |
| **OP 3** | **OP 4** | **OP 6** | **OP 7** | **OP8** | **OP9** | **OP10** |
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### Proposal 3.1-3

Study the following additional options for mitigating TRP Tx timing errors and/or UE Rx timing errors for DL TDOA:

* Option 11:
	+ Support the UE to report original RSTD measurements (uncompensated measurements) and related Rx TEGs information to the LMF
* Option 12:
	+ Support the UE to report the multiple RSTD measurements for a TRP with different UE Rx TEGs if the UE can measure the RSTD from the TRP with different UE Rx TEGs
* Option 13:
	+ Support UE to report multiple reference timings concerning multiple UE Rx TEGs for DL-TDOA,
* Option 14:
	+ Support TRP to provide the information of whether the Tx timing errors of DL PRS resources have been calibrated/pre-compensated locally within a certain margin to LMF
* Option 15:
	+ Support UE to report the statistics (variance) of RX TEGs to LMF
* Option 16:
	+ Support LMF to request a gNB to meet the association of the same antenna panel for DL-PRS transmission and SRS reception
* FFS: details of the signalling, procedures, and UE capability
* Note: Depending on the discussion results, none/one/multiple of the above options may be adopted in Rel-17.

Comments

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| --- | --- | --- |
| **Company** | **Support (Y)/Not Support(N)** | **Additional comments** |
| **OP 11** | **OP 12** | **OP 13** | **OP 14** | **OP15** | **OP16** |
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### Proposal 3.1-4

* Support a reference UE to provide the Tx timing error differences between Tx TEGs of the same or different TRPs to LMF.
* FFS: details of the signalling, procedures, and UE capability

Comments

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| **Company** | **Comments**  |
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## UE Tx and TRP Rx timing errors for UL TDOA

Background

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

|  |
| --- |
| Conclusion: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 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.
 |

FL Comments

The following table provides a summary of the opinions on the options for the mitigation of UE Tx and TRP Rx timing errors for UL TDOA [1-22].

Table 2 Summary of the opinions on the options for mitigating UE Tx and TRP Rx timing errors for UL TDOA

|  |  |
| --- | --- |
| **Options** | **Opinions from the companies** |
| **Support** | **Not support** | **Additional comments** |
| 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 | Huawei (multiple CCs), vivo, CATT, ZTE, CMCC, Intel, Nokia, MTK, CEWiT | Ericsson | OPPO(need to check feasibility) |
| 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. | Huawei (also add ports), Vivo, CATT, China Telecom, CMCC, ZTE, Intel , Nokia, MTK |  | OPPO(need to check feasibility) |
| Option 3: Support a UE to provide Tx timing errors per Tx TEG to LMF for UL TDOA positioning. | CATT, CMCC(if available), Intel | OPPO, Ericsson |  |
| Option 4: Support a UE to provide Tx timing error differences between Tx TEGs to LMF for UL TDOA positioning. | CATT, Intel, Nokia | OPPO, Ericsson |  |
|  |  |  |  |

**Additional proposals from the contribusions:**

* In [1], it was proposed to support a TRP to provide the association information of RTOA measurements with SRS resources/SRS ports to LMF when the TRP reports the RTOA measurements.
* In [1], it was proposed to support a UE to provide the statistics (variance, bound, etc.) of the Tx timing error differences between Tx TEGs to LMF for UL TDOA positioning
* In [4], it was proposed that the UE should provide the information of the UE Tx TEG(s) change associated with SRS resource(s) to the LMF if the UE Tx TEG is associated with SRS resource(s) changes.
	+ FFS how to provide this information to the LMF by the UE.
* In [4], it was proposed that if UE Tx TEG and Tx TEG associated with SRS resource(s) changes, the information should also be provided to the gNB performing SRS measurements,
* In [4], it was proposed that for UL-TDOA the RTOA measurement report for more than one UE Tx TEGs needs to be guaranteed if the gNB is able to measure SRS resources associated with different UE Tx TEGs.
* In [6], it was proposed to support TRP to provide the information to LMF that indicates whether the Rx timing errors of UL SRS resources have been calibrated/pre-compensated locally within a certain margin for UL-TDOA
* In [18], it was proposed that the estimated round-trip group delay and corresponding statistics at TRPs may also be reported to LMF to facilitate uplink RTD estimation for UL-TDOA technique.

From the feedback, it seems there is a consensus to support Option 2 (one company proposes to add ‘ports’ in addition to SRS resources). Option 1 is supported by the majority of companies, except one company considers the option is not needed. It is suggested to check if we can have them both agreed in the online session (see Proposal 3.2-1).

For the remaining options (Options 3, 4), there are two or more companies that have concerns. Thus, we may need to have a further discussion of them and determine which of them should be supported/not supported in el17 in the meeting (see Proposal 3.2-2).

For the additional options proposed from the interested companies in the meeting, we would need to study and collect companies’ views to determine which of them should/should not be included in Rel-17 (see Proposal 3.2-3)

### Proposal 3.2-1

* Support the following options for mitigating UE Tx timing errors and/or 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.
			* FFS: the association information of ports for the SRS transmission with UE Tx TEG(s) to LMF for UL TDOA positioning.
	+ FFS: the 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)
* Send an LS to RAN4 to check if there is any issue to support the above enhancements

Comments

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| **Company** | **Comments**  |
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### Proposal 3.2-2

Further study the options 3 and 4 (which was agreed to be studied in RAN1#104e) for mitigating UE Tx and TRP Rx timing errors for UL TDOA, and decide which of them should, or should not, be adapted in Rel-17 in this meeting.

Comments

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| **Company** | **Comments**  |
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### Proposal 3.2-3

Study the following additional option(s) for mitigating UE Tx and TRP Rx timing errors for UL TDOA:

* Option 5:
	+ Support a TRP to provide the association information of RTOA measurements with SRS resources/SRS ports to LMF.
* Option 6:
	+ Support a UE to provide the statistics (variance, bound, etc.) of the Tx timing error differences between Tx TEGs to LMF
* Option 7:
	+ Support a UE to provide the information of the UE Tx TEG(s) change associated with SRS resource(s) to LMF.
* Option 8:
	+ Support a UE to provide the information of UE UE Tx TEG(s) change associated with SRS resource(s) to a gNB
* Option 9:
	+ Support a TRP to provide the information to LMF that indicates whether the Rx timing errors of UL SRS resources have been calibrated/pre-compensated locally within a certain margin
* Option 10:
	+ Support a TRP to report the estimated round-trip group delay and corresponding statistics to LMF.
* FFS: the details of the signalling, procedures, and UE capability
* FFS: How the TEGs are determined by the UE or the TRP (could be by implementation, i.e., no specification impact)
* Note: Depending on the discussion results, none/one/multiple of the above options may be adopted in Rel-17.

Comments

|  |  |  |
| --- | --- | --- |
| **Company** | **Support (Y)/Not Support(N)** | **Additional comments** |
| **OP 5** | **OP 6** | **OP 7** | **OP 8** | **OP9** | **OP10** |
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## UE Rx/Tx timing errors in DL+UL positioning

Background

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

|  |
| --- |
| Conclusion:Study the following options for mitigating UE Rx/Tx timing errors in DL+UL positioning: * Option 1:
	+ Support UE to provide the association information of UE Rx-Tx time difference measurements with UE Rx TEGs in the measurement report to LMF
* Option 2:
	+ Support UE to provide the association information of UE Rx-Tx time difference measurements with UE Tx TEGs in the measurement report to LMF
* Option 3:
	+ Combination of Option 1 and Option 2;
* Option 4:
	+ Support UE to provide the association information of UE Rx-Tx time difference measurements with UE RxTx TEGs in a measurement report to LMF for multi-RTT positioning
		- FFS: the definition of UE RxTxTEG. It includes both UE Rx timing and Tx timing errors.
* Option 5:
	+ Support UE to provide the association information of DL-RSTD measurements with UE RxTx TEGs in a measurement report to LMF for simultaneous DL-TDOA and UL-TDOA configuration for positioning
* Option 6:
	+ Support UE to provide the timing errors per Rx/Tx TEG, or the timing error differences between the Tx/Rx TEGs to LMF
* Option 7:
	+ Support UE to provide the timing errors per RxTx TEG, or the Tx timing error differences between the RxTx TEGs to LMF
* FFS: the details of signaling, 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.
 |

FL Comments

The following table provides a summary of the opinions on the options for the mitigation of UE Rx/Tx timing errors in DL+UL positioning [1-22].

Table 3 Summary of the opinions on the options for mitigating UE Rx/Tx timing errors in DL+UL positioning

|  |  |
| --- | --- |
| **Options** | **Opinions from the companies** |
| **Support** | **Not support** | **Additional comments** |
| Option 1: Support UE to provide the association information of UE Rx-Tx time difference measurements with UE Rx TEGs in the measurement report to LMF | vivo, CATT, ZTE, China Telecom, CMCC, Intel, , Nokia |  | OPPO(need to check feasibility) |
| Option 2: Support UE to provide the association information of UE Rx-Tx time difference measurements with UE Tx TEGs in the measurement report to LMF | CATT, ZTE, CMCC, Intel, Nokia, MTK(TX antenna panel or TEG) |  | OPPO(need to check feasibility) |
| Option 3: Combination of Option 1 and Option 2; | CATT, ZTE, CMCC, Intel, , Nokia |  | OPPO(need to check feasibility) |
| Option 4: Support UE to provide the association information of UE Rx-Tx time difference measurements with UE RxTx TEGs in a measurement report to LMF for multi-RTT positioning FFS: the definition of UE RxTxTEG. It includes both UE Rx timing and Tx timing errors. | Huawei(same UE RxTx TEG), vivo, Qualcomm |  | OPPO(need to check feasibility) |
| Option 5: Support UE to provide the association information of DL-RSTD measurements with UE RxTx TEGs in a measurement report to LMF for simultaneous DL-TDOA and UL-TDOA configuration for positioning |  |  | OPPO(need to check feasibility) |
| Option 6: Support UE to provide the timing errors per Rx/Tx TEG, or the timing error differences between the Tx/Rx TEGs to LMF | Intel | OPPO, Ericsson |  |
| Option 7: Support UE to provide the timing errors per RxTx TEG, or the Tx timing error differences between the RxTx TEGs to LMF | Qualcomm | OPPO, Ericsson |  |

**Additional proposals from the contributions:**

In [6], it was proposed that for option 2, support the following reporting of UE Tx TEG ID associated with each Rx-Tx time difference measurement and SRS resource ID/resource set ID along with the Rx-Tx time difference measurements.

In [18], it was proposed that for M-RTT, UE and gNB may report the statistics (variance, uncertainty level) of the round-trip group delay of the associated antenna panel. Round-trip group delay compensation should have been done before reporting.

In [19], it was proposed that for timing measurement with different Rx/Tx TEGs, following parameter for measurement report and/or assumption for measurement can be specified: TEG ID or value (e.g. timing margin or offset) in measurement report; and ensuring same Rx/Tx TEGs at both UE and TRP within the measurement time window;

In [20], it was proposed that for mitigating UE Rx/Tx timing errors in DL+UL positioning methods consider the impact internal UE clock accuracy and drift for RxTx timing errors per RxTx TEG and Tx timing errors per Tx TEG.

Based on the feedback, for supporting DL+UP positioning it seems there are different views on whether to use two separate TEGs (Rx TEG and Tx TEG) for Tx timing error and Rx timing error (Option 1, 2, 3) or use one combined TEG (RxTx TEG) (Option 4). We may remove Option 5, since it seems no company supports it. More discussion is needed for Option 6 and 7 since at least two companies do not support them. The suggestion is to continue discussing Option 1-4, 6-7 and making the decision on which of them should be supported/not supported in the meeting (see Proposal 3.3-1).

For the additional options proposed in the meeting from the interested companies, we would need to first study and collect companies’ views on which of them should/should not be included in Rel-17 (see Proposal 3.3-2). The proposals related to the details of the signaling parameters may be considered later once we have determined which of the options are adopted.

### Proposal 3.3-1

Further study the options 1, 2, 3, 4, 6, and 7 (which was agreed to be studied in RAN1#104e) for mitigating UE Rx/Tx timing errors in DL+UL positioning, and decide which of them should, or should not, be adapted in Rel-17 in this meeting.

Comments

|  |  |  |
| --- | --- | --- |
| **Company** | **Support (Y)/Not Support(N)** | **Additional comments** |
| **OP 1** | **OP 2** | **OP 3** | **OP 4** | **OP6** | **OP7** |
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### Proposal 3.3-2

Study the following additional options for mitigating UE Rx/Tx timing errors in DL+UL positioning:

* Option 7:
	+ Support a UE to report the statistics (variance, uncertainty level) of the UE RxTx TEGs to LMF
		- Note: UE round-trip group delay compensation should have been done before reporting.
* Option 8:
	+ Consider the impact of UE internal clock accuracy and drift for RxTx timing errors per RxTx TEG and Tx timing errors per Tx TEG for mitigating TRP Rx/Tx timing errors in DL+UL positioning.

Comments

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| --- | --- | --- |
| **Company** | **Support (Y)/Not Support(N)** | **Additional comments** |
| **OP7** | **OP8** |
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## gNB Rx/Tx timing errors for DL+UL positioning

Background

The following conclusion was made in RAN1#104e, related to the option(s) for mitigating gNB Rx/Tx timing errors in DL+UL positioning.

|  |
| --- |
| Conclusion:Study the following options for mitigating gNB Rx/Tx timing errors in DL+UL positioning: * Option 1:
	+ Support TRP to provide the association information of gNB Rx-Tx time difference measurements with TRP Rx TEGs in the measurement report to LMF
* Option 2:
	+ Support TRP to provide the association information of gNB Rx-Tx time difference measurements with TRP Tx TEGs in the measurement report to LMF
* Option 3:
	+ Combination of Option 1 and Option 2;
* Option 4:
	+ Support TRP to provide the association information of gNB Rx-Tx time difference measurements with TRP RxTx TEGs in a measurement report to LMF for multi-RTT positioning
* Option 5:
	+ Support TRP to provide the timing errors per Rx/Tx TEG, or the timing error differences between the Tx/Rx TEGs to LMF
* Option 6:
	+ Support TRP to provide the timing errors per RxTx TEG, or the Tx timing error differences between the RxTx TEGs to LMF
* FFS: the details of signalling and procedures
* 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.
 |

FL Comments

The following table provides a summary of the opinions on the options for the mitigation of gNB Rx/Tx timing errors in DL+UL positioning[1-22].

Table 4 Summary of the opinions on the options for mitigating TRP Rx/Tx timing errors in DL+UL positioning

|  |  |
| --- | --- |
| **Options** | **Opinions from the companies** |
| **Support** | **Not support** | **Additional comments** |
| Option 1: Support TRP to provide the association information of gNB Rx-Tx time difference measurements with TRP Rx TEGs in the measurement report to LMF | CATT, ZTE, Intel, China Telecom, Nokia | Ericsson | OPPO(need to check feasibility) |
| Option 2: Support TRP to provide the association information of gNB Rx-Tx time difference measurements with TRP Tx TEGs in the measurement report to LMF | CATT, ZTE, Nokia Intel, MTK(TX antenna panel or TEG) | Ericsson | OPPO(need to check feasibility) |
| Option 3: Combination of Option 1 and Option 2; | CATT, ZTE, Nokia, Intel | Ericsson | OPPO(need to check feasibility) |
| Option 4: Support TRP to provide the association information of gNB Rx-Tx time difference measurements with TRP RxTx TEGs in a measurement report to LMF for multi-RTT positioning | Huawei(multiple CCs), Qualcomm | Ericsson | OPPO(need to check feasibility) |
| Option 5: Support TRP to provide the timing errors per Rx/Tx TEG, or the timing error differences between the Tx/Rx TEGs to LMF | Intel | OPPO, Ericsson |  |
| Option 6: Support TRP to provide the timing errors per RxTx TEG, or the Tx timing error differences between the RxTx TEGs to LMF | Qualcomm | OPPO, Ericsson |  |

**Additional proposals from the contributions:**

In [6], it was proposed to support TRP to provide the information to LMF that indicates whether the Rx timing errors of UL SRS resources and Tx timing errors of DL PRS resources have been calibrated/pre-compensated locally within a certain margin.

In [18], it was proposed that for M-RTT, UE and gNB may report the statistics (variance, uncertainty level) of the round-trip group delay of the associated antenna panel. Round-trip group delay compensation should have been done before reporting.

Based on the feedback, for supporting DL+UP positioning it seems there are different views on whether to use two separate TEGs (Rx TEG and Tx TEG) for Tx timing error and Rx timing error (Option 1, 2, 3, and 5) or use one combined TEG (RxTx TEG) (Option 4 and 6). One company considers none of the options is needed. Thus, we may need more discussion on the options to be adopted in Rel-17. The suggestion is to continue discussing them and making the decision on which of them should be supported/not supported in the meeting (see Proposal 3.4-1).

For the additional options proposed in the meeting from the interested companies, we would need to first study and collect companies’ views on which of them should/should not be included in Rel-17 (see Proposal 3.4-2). The proposals related to the details of the signaling parameters may be considered later once we decide which of the options are adopted.

### Proposal 3.4-1

Further study the options 1, 2, 3, 4, 5, and 6 (which was agreed to be studied in RAN1#104e) for mitigating TRP Rx/Tx timing errors in DL+UL positioning, and decide which of them should, or should not, be adapted in Rel-17 in this meeting.

Comments

|  |  |  |
| --- | --- | --- |
| **Company** | **Support (Y)/Not Support(N)** | **Additional comments** |
| **OP 1** | **OP 2** | **OP 3** | **OP 4** | **OP5** | **OP6** |
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### Proposal 3.4-2

Study the following additional options for mitigating TRP Rx/Tx timing errors in DL+UL positioning:

* Option 7:
	+ Support a TRP to provide the information to LMF that indicates whether the Rx timing errors of UL SRS resources and Tx timing errors of DL PRS resources have been calibrated/pre-compensated locally within a certain margin.
* Option 8:
	+ Support a TRP to report the statistics (variance, uncertainty level) of the TRP RxTx TEGs to LMF
		- Note: TRP round-trip group delay compensation should have been done before reporting.

Comments

|  |  |  |
| --- | --- | --- |
| **Company** | **Support (Y)/Not Support(N)** | **Additional comments** |
| **OP7** | **OP8** |
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# 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:

|  |
| --- |
| 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 signalling, 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
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Submitted Proposals

* (Huawei [R1-2102348](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102348.doc)) Proposal 8: Support to enable a reference UE to mitigate Rx/Tx timing error of gNB.
* (Huawei [R1-2102348](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102348.doc)) Proposal 9: 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.
* (BUPT [R1-2102364](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102364.doc)[2]) Proposal 1: A calibration UE with the known position is introduced to reduce the gNB timing error
* (OPPO [R1-2102399](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102399.doc) [3]) Proposal 13: Implementation based approach (Approach 2) is supported for the positioning based on reference device(s) with known location.
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])Proposal 13:
	+ Support reference devices of two types: pre-deployed UEs, normal UEs.
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])Proposal 14:
	+ Specify the procedure for the LMF to determine the ‘reference UEs’ from normal UEs.
		- e.g. including LMF requesting UE capability information and/or related location information, UE reporting capability information and/or related location information, etc.
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])Proposal 15:
	+ Support the ‘reference UE’ 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 UE’
		- support the LMF to indicate the mobility or the motion trajectory of the ‘reference UE’
* (vivo [R1-2102526](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102526.doc) [4])Proposal 16:
	+ The location information of ‘reference UE’ can be provided to the gNB for angle error calibration by itself.
* (CATT [R1-2102635](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102635.doc)[5]) Proposal 17: 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 [R1-2102635](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102635.doc)[5]) Proposal 18: 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 [R1-2102635](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102635.doc)[5]) Proposal 19: 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.
* (CMCC [R1-2102886](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102886.doc)[8]) Proposal 1: Support the reference device with the known location being a UE.
* (CMCC [R1-2102886](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102886.doc)[8]) Proposal 2: Support the reference device with the known location being a gNB.
* (CMCC [R1-2102886](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102886.doc)[8]) Proposal 3: Support the reference device to report its identity and the location information via capability transfer signalling.
* (CMCC [R1-2102886](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102886.doc)[8]) Proposal 4: Support signalling enhancements to allow the reference device using UE-based positioning to report the estimated timing errors.
* (Nokia [R1-2103002](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103002.doc)[9])Proposal 3: 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.
* (InterDigital [R1-2103005](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103005.doc) [10]) Proposal 1: Specification impact of reference devices includes at least assistance information which contains at least reference device ID, locations of reference devices
* (InterDigital [R1-2103005](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103005.doc) [10]) Proposal 2: Study positioning procedures to support differential positioning techniques
* (InterDigital [R1-2103005](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103005.doc) [10]) Proposal 3: A reference device is classified as a UE
* (InterDigital [R1-2103005](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103005.doc) [10]) 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 [R1-2103035](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103035.doc)[11])Proposal 1:
	+ Support solution where reference device is a reference UE with known coordinates and a certain timing error margin specified for each TEG, if reference UE uses multiple TEGs for signals transmission and reception
	+ Note: the solution with a reference UE may benefit from reusing of the UL SRS and DL PRS structure, already defined in the specification
* (Intel [R1-2103035](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103035.doc)[11])Proposal 2:
	+ Specify reporting format of reference device coordinates from a reference device to LMF/gNB
* (Intel [R1-2103035](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103035.doc)[11])Proposal 3:
	+ Specify reporting format of reference device timing error margin per TEG (if it uses multiple TEGs for transmission and reception) from a reference UE to LMF/gNB
* (Qualcomm [R1-2103170](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103170.doc)[13])Proposal 3: Support a device to be used as a “Reference Location Device (RLD)” for the purpose of enabling improved positioning accuracy by timing error and angular error mitigation.
	+ Up to RAN2 to continue the specification work (and how/if to enable a UE/gNB to be a RLD).
* (Samsung [R1-2103243](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103243.doc)[14])Proposal 1:
	+ At least calibration based on a known location is supported for UE and gNB.
	+ The derived timing error can be compensated at TRP, or UE, or LMF.
* (Sony [R1-2103306](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103306.doc)[15]) Proposal 1: Support to use reference UE for UE and gNB RX/TX timing delays mitigation.
* (Sony [R1-2103306](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103306.doc)[15]) Proposal 2: Define a mechanism to enable any UEs become a reference UE (Reference UE Identification).
* (Sony [R1-2103306](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103306.doc)[15]) Proposal 3: Support to study the signaling and mechanism to enable and disable the reference UEs, including providing the reference UE requirement information.
* (Sony [R1-2103306](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103306.doc)[15]) Proposal 4. Support reference UE to report the estimated gNB Tx timing error to the LS when using DL-based positioning method.
* (Sony [R1-2103306](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103306.doc)[15]) Proposal 5. Support reference UE to report the UE Tx timing error and optionally, the estimated UE location to the gNB.
* (Lenovo [R1-2103372](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103372.doc)[16])Proposal 1: Existing capability and assistance data transfer messages can be used to configure the reference device. Additional reference device capability information is needed and RAN2 to confirm the impacts (if any) of configuring and scheduling a reference device.
* (Lenovo [R1-2103372](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103372.doc)[16])Proposal 2: RAN1 to support UEs and TRPs as reference devices.
* (Lenovo [R1-2103372](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103372.doc)[16])Proposal 3: Reference UE can report its location estimate information using existing LPP signalling methods.
* (Lenovo [R1-2103372](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103372.doc)[16])Proposal 4: Reference UE can include positioning QoS information as part of its location estimate report to determine the quality of the location estimate.
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-5: For reference device approach, the pre-configured reference device is considered in Rel-17, and the dynamic reference device could be studied in the future
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-6: For reference device approach, we consider UE as the reference device, because there is flexibility to allocate the position within a cell. IAB-MT also behaves like a UE, which is also suitable as reference device
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-7: For reference device approach, since the reference UEs within a cell have the known positions in a priori during cell deployment, the gNB may report the positions, and the corresponding IDs which can identify the reference UEs to the location server through higher layer signaling
* (MediaTek [R1-2103600](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)[18])Proposal 4a-8: For reference device approach, the reference UEs may just follow same reporting format as the normal UEs for positioning.
* (Fraunhofer [R1-2103681](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103681.doc)[20])Proposal 3:
	+ Support the reference device being a UE with known location
	+ Do not support reference device specific signalling and measurements of the Rx and Tx timing delays
* (CEWiT [R1-2103682](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103682.doc)[21])Proposal 4: Reference node for timing error estimation can be UE or gNB/TRP whose location is precisely known. Candidate node should share capability of being reference node for timing error calibration with LMF including precise position.
* (CEWiT [R1-2103682](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103682.doc)[21])Proposal 5: For UE as reference node,
	+ In case of UE assisted positioning, UE can be configured with existing positioning method for timing error calibration. There is no specification impact.
	+ In case of UE based positioning, LMF need to convey the timing error to UE to mitigate the timing error from positioning estimation.
* (CEWiT [R1-2103682](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103682.doc)[21])Proposal 6: For gNB configured as reference node, gNB should be capable of receiving PRS signal and should report the performed measurement to the LMF.
* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 20 No reference device should be specified in Rel. 17.

FL Comments

Based on the feedback, majority companies supports enabling a UE as a reference device for mitigating Rx/Tx timing errors ((1], [2], [3].[4], [5], [8], [9], [10], [13], [14], [15], [16], [18], [20], [21], [22]). A few companies als supports enabling a gNB as a reference device for mitigating Rx/Tx timing errors ([8].[11],[14],[16],[21]), and one company also proposes a IAB-MT as a reference device [17].

For the impact on the specification, majority companies (([1],[4],[5],[8],[9],[10],[13],[14],[15],[16],[17],[18],[21]) consider there are specification impact. More specifically,

* signalling the report of device information (e.g., ID and location coordinate, etc.) to the LMF ([1], [5], [8], [10]. [11],[16],[18]),
* specify the procedure for the LMF to determine the ‘reference UEs’ from normal UEs [4]
* enable/disable a UE as the ‘reference UE’ [5]
* the report of additional measurement information from reference UE to support the calibration (e.g., estimated Rx/Tx timing errors ([5],[8].[[10],15])
* the report of UE location coordinate information to the gNB ([4], [11]
* the report of additional measurement information from reference gNB to LMF [21]
* up to RAN2 to continue the specification work [13]

In addition, some companies consider whether to support being a reference UE can be a UE capability([4],[8],[16],[21]).

### Proposal 4-1

* Rel-17 should support enabling a device with a known location to be a reference device to mitigate the UE/gNB Rx/Tx timing errors.
	+ The reference device can be a UE that is preconfigured as a reference device
	+ A normal UE can be dynamically enabled/configured as a reference device, which is subject to the UE’s capability
	+ FFS: a TRP can be enabled as a reference device
* A reference device UE should support
	+ measuring DL PRS and report associated existing positioning measurements (e.g., RSTD, Rx-Tx time difference, and RSRP) to the LMF
	+ reporting its location coordinate information and, optionally, the precision of the location to the LMF
	+ transmitting SRS for positioning if configured by the gNB
		- In this case, the TRPs can be enabled by the LMF to measure and report existing positioning measurements (e.g., RTOA, Rx-Tx time difference, AOA) associated with the reference device to the LMF
* The details of the signalling, the measurements, the parameters for supporting a device with a known location to be a reference device will be defined by RAN2;
* RAN2/RAN3 should be informed on RAN1 conclusion/agreement if necessary.

Comments

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| **Company** | **Comments**  |
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# 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 signalling, 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.
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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. 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 above agreement, which are summzried as follows:

* About the timestamp for a measurement instance:
	+ Specifying the time stamp selection for each measurement instance and scattering the measurement instances throughout the measurement time [1]
	+ enable the UE to report PRS measurements derived from the most recent measurement instances in advance of a certain time before the measurement report, which is related to PRS processing capability [4]
	+ the time stamp of the measurement instance corresponds to one time instance between the first and the last DL-PRS resource set (or SRS-Pos resource set) contained by the measurement instance, or corresponds to one time instance between the first and the last contained by the measurement instance [5]
	+ the time stamp is a time window indicated by a starting time stamp that corresponds to a reception time of the first reference signal for determining a measurement instance, and an ending time stamp that corresponds to a reception time of the last reference signal for determining the measurement instance [6]
* About the measurement time window for the measurement instances:
	+ Measurement time windows should be configurable [5]
	+ UE and TRP measurement time windows should be configurable independently [5]
	+ UE or TRP is not expected to report the measurement instances outside of the measurement time window [5]
	+ Support a “Location Time or Time-domain Window” configuration to both UE and gNBs that defines the time at which the measurements are to be obtained[13]
	+ Define UE behavior when a limited number (or none) PRS instance appears within a configured time-domain window[13]
	+ Measurement time window should be based on (N,T) DL-PRS processing UE capability [16]
	+ Ensuring same Rx/Tx TEGs at both UE and TRP within the measurement time window [19]
	+ It shall be possible to configure the measurement window for a measurement instance to be so short that there is no risk for the associated delay group(s) to change during the measurement window[22]
* About each UE measurement instance can be configured with N instances of the DL-PRS Resource Set,
	+ “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 [4]
	+ N=[1,…,256] ([5]])
	+ Consider at least the following alternatives: configured by LMF per DL PRS resource set.; configured by LMF per TRP; configured by LMF per positioning frequency layer; and configured by LMF per measurement report [6]
	+ Support LMF requesting the UE or gNB to perform measurements on specific PRS/SRS resources across multiple time-domain instances [13]
* About each TRP measurement instance can be configured with M SRS measurement time occasions
	+ M=[1, …, 256] ([5])
	+ Support LMF requesting the UE or gNB to perform measurements on specific PRS/SRS resources across multiple time-domain instances [13]
* About the details of signalling, procedures, there are different proposals, e.g.,
	+ Potential extension of LPP to support a larger number than 4 measurement instances in a single measurement report from UE[3]
	+ No enhancement is needed for the current NRPPa signaling to support multipe measurement instances in a single measurement report from gNB [3]
	+ Enhancement on the association of measurement instances to support the feature that TRP reports one or more measurement instances with different quantities in a single measurement report [3]
	+ The measurement time windows are configured with the parameters of the start time, the periodicity, the number of measurement instances, and the number of instances of PRS/SRS resource sets; or the start time, the periodicity, and the length of the window [5]
	+ The UE or the TRP can be configured to report one or more measurement instances in a single measurement report to the LMF[4]
	+ Support reporting the parameters related to gNB Rx/Tx timing errors from gNB to LMF for UE-assisted positioning (or from gNB/LMF to UE for UE-based positioning) [5]
	+ Further discuss the association between measurement instances and UE measurement report, at least consider one of the following options: multiple measurement instances are associated with the indicated DL PRS resource or the indicated DL PRS resource set; multiple measurement instances are associated with the indicated measurement element; multiple measurement instances are associated with the indicated positioning method; or multiple measurement instances are directly associated with a measurement report [6]
	+ 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) [12]
	+ Support UE group indication reporting of DL-PRS resources associated to a measurement instance group (can include one or more measurement instances) for easier management of multiple time stamp reporting within a single measurement report[16]
	+ For timing measurement with different Rx/Tx TEGs, following parameter for measurement report and/or assumption for measurement can be specified: TEG ID or value (e.g. timing margin or offset) in measurement report [19]
	+ The TEG association is reported independently for each measurement instance in a measurement report.[22]
* About the additional enhancement related to measurement reporting of multi-paths and quality metric:
	+ The existing UE timing quality indication can be extended to indicate the quality of timing-based measurement instances [16]
* About the UE capability
	+ Support 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.[4]
	+ Measurement time window should be based on (N,T) DL-PRS processing UE capability [16]
	+ 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 [12];

Based on the proposals from the interested companies, it is suggested to further discuss: a) whether to introduce the measurement time window for the measurement instance; b) how the timestamp is defined for each measurement instance, and c) the number of instances of the DL-PRS/UL-SRS Resource Set for a UE/TRP measurement instance. Once we reach the consensus on these issues, we will then work on more details related to the signalling, procedures, UE capability, etc.

### Proposal 5-1

* The timestamp for a measurement instance is defined by one of the following options:
	+ Option 1:
		- The timestamp of a measurement instance is within a time selection that is configured (or defined) for the measurement instance;
	+ Option 2:
		- The timestamp of the measurement instance corresponds to a time 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.

Comments

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| **Company** | **Comments**  |
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### Proposal 5-2

* One of the following options are adopted related to the measurement time window for a measurement report:
	+ Option 1:
		- A measurement time window is configured (or defined) for the time at which the measurements are to be obtained
			* FFS: whether the measurement time windows can be configurable for both UE and TRP independently and the details of the configuration parameters
			* FFS: whether the measurement time window is defined based on (N,T) DL-PRS processing UE capability
			* FFS: UE behavior within a configured time window (e.g., same Rx/Tx TEGs at both UE and TRP within the measurement time window)
	+ Option 2:
		- No measurement time window is defined or configured for the measurement instances

Comments

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| **Company** | **Comments**  |
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### Proposal 5-3

* 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]
	+ 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]
	+ Option 2: M is decided by RAN4

Comments

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

## Antenna array phase center offset

Submitted Proposals

* (Huawei [R1-2102348](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102348.doc)) Proposal 1:
	+ The enhancement to mitigate UE/TRP Rx/Tx timing error should deprioritize particular enhancements towards the UE phase centre offset on different beams, which also creates ARP drift.
* (Nokia [R1-2103002](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103002.doc)[9])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 [R1-2103002](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103002.doc)[9])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.

FL comments

The phase center offsets may be different for different antenna panels and different beam directions, which may be seen also as timing delays, and have an impact on the measurement and positioning accuracy. The introduction of the concept of timing error groups may address, to a certain degree, the impact of the antenna array phase centers on the measurement and positioning accuracy. The impact of the antenna array phase center offsets on the mitigating UE/gNB Tx/Rx timing errors were discussed in the last meeting without conclusion.

### Proposal 6.1-1

* Support UE to report gNB specific SRS-Pos TOD offsets to gNB/LMF for enhancing the positioning accuracy.
* Support UE to signal to gNB/LMF its capability 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

Comments

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| **Company** | **Comments**  |
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## TA reports

Submitted Proposals

* **(MediaTek** [**R1-2103600**](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103600.doc)**[18])Proposal 4d-1**: For M-RTT, the delta adjustment of TA, which is between the applied TA for UE RX-TX time difference measurement and for actual SRS transmission for gNB RX-TX time difference measurement, may report to the location server.

FL Comments

The adjustment of TA during a multi-RTT positioning procedure without proper handing the change of the UE time may certainly impact UE Rx-Tx time difference measurements. In addition to reporting the TA changes to LMF, another possible way is the UE delays the TA changes during RTT positioning procedure, or the UE includes the TA changes into the UE Rx-Tx time difference measurements.

### Proposal 6.2-1

* Support UE to report the delta adjustment of TA, which is between the applied TA for UE RX-TX time difference measurement and for actual SRS transmission for gNB RX-TX time difference measurement, to LMF for Multi-RTT positioning.

Comments

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| **Company** | **Comments**  |
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## The spatial relation of SRS with DL PRS or SSB

Submitted Proposals

* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 3 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 [22] 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 6.3-1

* Further study the configuration of 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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## Beam and delay group sweeping

Submitted Proposals

* (Ericsson [R1-2103771](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103771.doc)[22])Proposal 4 RAN1 should study beam and UE TX TEG sweeping further and consider this method to reduce positioning overhead for specification in Rel. 17.

FL comments

Consider a UL beam may be transmitted with different antenna panels with different Tx timing errors, it was proposed in [19] to further study the beam and delay group sweeping to reduce positioning overhead.

### Proposal 6.4-1

* Further study beam and UE TX TEG sweeping and consider this method to reduce positioning overhead for specification in Rel. 17

Comments

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## Others

Submitted Proposals

* (Samsung [R1-2103243](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103243.doc)[14])Proposal 3: Improve the TA granularity for TA report in E-CID.
* (Samsung [R1-2103243](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2103243.doc)[14])Proposal 4: Positioning in RRC inactive state should be supported.

FL comments

TA granularity for TA report in E-CID above is not included in the scope of Rel-17 WI. Positioning enhancement for RRC inactive is not on the agenda of this meeting. Suggest no further discussion of the above proposals in this meeting.

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| **Company** | **Comments**  |
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3. [R1-2102399](file:///E%3A%5C1%20Meetings%5CRAN1%5CDocs%5CR1-2102399.doc) Enhancement of timing-based positioning by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays OPPO
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