**3GPP TSG RAN WG1 Meeting #104-e R1-2102122**

**e-meeting, January 25th – February 5th, 2021**

**Source: Moderator (CATT)**

**Title: FL Summary #4 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:

[104-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 Jan-28, Feb-02, Feb-05 – Ren Da (CATT)

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

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

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

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| 2 Methods of mitigating UE/gNB Rx/Tx timing delays  3 Mitigation of Rx/TX timing delays  3.1 Rx/Tx timing error groups  3.2 Mitigating gNB Tx timing errors (for RSTD and DL positioning)  3.3 Mitigating gNB Rx timing errors for UL RTOA  3.4 Mitigating UE Tx timing errors for UL RTOA  3.5 Mitigating UE Rx timing errors for RSTD  3.6 Mitigating Tx/Rx timing errors for multi-RTT positioning  3.7 Feasibility/Capability of the calibration of UE/gNB Tx/Rx timing errors  4 Additional proposals  4.1 Measurement Enhancements  4.2 Antenna array phase center offset  4.3 Spatial relation of SRS with DL PRS or SSB  4.4 Beam and delay group sweeping |

**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.

# Methods of mitigating UE/gNB Rx/Tx timing delays

Submitted Proposals (related to the methods of mitigating UE/gNB Rx/Tx timing delays)

* (Huawei [R1-2100195](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100195.doc)) Proposal 1:
  + Introduce a calibration UE with the known location to mitigate the gNB timing error.
* (ZTE [R1-2100293](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100293.doc)) Proposal 2:
  + In order to mitigate the Tx/Rx timing delay for DL-TDOA/UL-TDOA positioning method, considering the following enhancements in Rel-17
    - The TRP should have capability to do mutual-calibration and feed back the Tx timing delay difference and Rx timing delay difference.
    - For UE based positioning, network should provide TRP-side Tx timing delay difference in assistance data.
    - Provide by network or report by UE to indicate whether UE uses the same RF chain to transmit or receive signals from different TRPs.
* (CAICT [R1-2100308](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100308.doc))Proposal 1:
  + Differential positioning technique could be considered to compensate synchronization error and Rx/Tx transmission delays.
* (CATT [R1-2100385](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100385.doc)) Proposal 4:
  + NR Rel-17 should support the methods of mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays based on a double differential scheme with a reference UE.
* (vivo [R1-2100445](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100445.doc))Proposal 1
  + ‘Reference UE’ based differential positioning method should be supported to assist UE and gNB Rx/Tx timing delay mitigating.
    - ‘The reference UE’ can measure/transmit positioning signals from/to multiple TRPs and report the measurement results to the LMF as normal UEs
    - The accurate and reliable location of ‘the reference UE’ should be known by the LMF and the UE itself
* (vivo [R1-2100445](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100445.doc))Proposal 2
  + AoA-based RX/TX timing delay mitigating method should be considered as an alternative method to ‘reference UE’ based differential positioning method.
* (Nokia [R1-2100548](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100548.doc)) Proposal 2:
  + To mitigate UE and gNB Rx/Tx timing delays a solution not relying on reference devices should be specified if possible.
* (Apple [R1-2101387](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101387.doc)) Proposal 1:
  + In order to estimate and correct the effective timing error, support in Rel-17 timing calibration, using reference points (UE/gNB) with precise location information known to the network.
* (Intel [R1-2100657](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100657.doc)) Proposal 1:
  + Inter-gNB (or TRP) calibration procedure to estimate TX/RX timing errors is left up to network implementation
  + Define gNB TX/RX timing errors measurement report formats to report the data from gNB to LMF (or gNB/LMF to UE)
* (Intel [R1-2100657](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100657.doc)) Proposal 2 (General solution targeting all timing-based positioning methods):
  + Support gNB TX/RX timing errors measurement report signaling from gNB to LMF (or gNB/LMF to UE), including the following information/measurements
    - Alt.1:
      * Measured propagation time (*ti-j*) between gNBs
      * Reference propagation time (*Tij*) between *i*th and *j*th nodes (gNBs or TRPs) derived based on known gNB coordinates
    - Alt.2:
      * Difference of the above measurements, i.e. Δ*ti-j* = *ti-j* - *Tij*
* (CMCC [R1-2101046](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101046.doc)) Proposal 1:
  + For TDOA-based positioning, a unified framework to estimate Tx/Rx timing errors and NW synchronization error can be defined.
* (CMCC [R1-2101046](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101046.doc)) Proposal 2:
  + Support the measurement and reporting among the TRPs to estimate the timing errors.
* (CMCC [R1-2101046](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101046.doc)) Proposal 3:
  + Support the enhancement of jointly using timing-based and angle-based method to improve the accuracy in the presence of Rx/Tx transmission delays.
* (MediaTek [R1-2101140](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101140.doc)) Proposal 2-1:
  + The mitigation of RX/TX timing delays could be achieved by 1), conduct the calibration to derive the analog domain delay 2), adopt the positioning methods using differential measurements.
* (MediaTek [R1-2101140](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101140.doc)) Proposal 2-3:
  + Consider the combination of measurements for DL-TDOA and UL-TDOA, which is able to handle the synchronization error and to reduce the impact of timing delays
* (Qualcomm [R1-2101468](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101468.doc)) Proposal 2:
  + Support mechanisms and signaling to enable PRS reception by TRPs and associated reporting of gNB measurements derived on PRS reception and/or PRS transmission timing.
    - FFS: Signaling details and procedures

Submitted Proposals related to joint measurements for mitigating UE/gNB Rx/Tx timing errors

* (OPPO [R1-2100128](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100128.doc)) Proposal 3:
  + For DL TDOA positioning, Rel-17 can support the joint measurement of timing based and angle based positioning per DL PRS resource.
* (OPPO [R1-2100128](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100128.doc)) Proposal 4:
  + For UE-assisted DL TDOA positioning, Rel-17 can support the joint report of timing based and angle based positioning per DL PRS resource.
* (OPPO [R1-2100128](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100128.doc)) Proposal 6:
  + For NR UL RTOA based positioning, Rel-17 can support the joint measurement and report of UL timing based and UL angle based positioning for the SRS resources for positioning.
* (OPPO [R1-2100128](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100128.doc)) Proposal 8:
  + For multi-RTT positioning, Rel-17 can support the joint measurement and report of multi-RTT based positioning and UL angle based positioning on the SRS resources for positioning.
* (CMCC [R1-2101046](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101046.doc)) Proposal 3:
  + Support the enhancement of jointly using timing-based and angle-based method to improve the accuracy in the presence of Rx/Tx transmission delays.
* (vivo [R1-2100445](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100445.doc))Proposal 2
  + AoA-based RX/TX timing delay mitigating method should be considered as an alternative method to ‘reference UE’ based differential positioning method.
* (MediaTek [R1-2101140](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101140.doc)) Proposal 2-3:
  + Consider the combination of measurements for DL-TDOA and UL-TDOA, which is able to handle the synchronization error and to reduce the impact of timing delays
* (Qualcomm [R1-2101468](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101468.doc)) Proposal 3:
  + Support enhancements in the reporting of the positioning measurements (from the UE and the gNB) to enable reporting in a single report multiple measurements:
    - Enable multiple measurement reporting in a single report with timestamps derived on the same TRP & PRS resources

FL comments

From the above-submitted proposals, different methods were proposed for the estimation/calibration/elimination of the UE/gNB Rx/Tx timing delays, which may be grouped into the following categories:

**Method 1:** UE/gNB TX/RX timing errors are estimated/calibrated by the use of the existing timing measurements (e.g., RSTD, RTOA, UE/gNB Rx-Tx time differences) (e.g., [1][2]),

**Method 2:** UE/gNB TX/RX timing errors are estimated/calibrated with the combination of the existing timing and angle measurements (e.g., RSTD, UE Rx-Tx time difference, AOA/AOD) (e.g., [1] [2][12])

**Method 3:** gNB TX/RX timing errors are estimated/calibrated based on the DL PRS measurements provided by TRPs (e.g., [3][8][12][17])

**Method 4:** UE/gNB TX/RX timing errors are estimated/calibrated based on the DL PRS measurements provided by UEs at known locations (e.g., reference/calibration UEs) with differential techniques (e.g., [2][4][5][6][14][16])

For methods 1 and 2, enhancements of measurement reporting (e.g., both the timing and angle measurements) may be needed for both UE and gNB. For example, a UE/TRP needs to provide both timing and angle measurements, which are obtained from the same DL PRS resources and/or UL SRS resources, in a single measurement report (e.g., [1][6][14][17])

For methods 3, it may require the enhancement for a TRP to measure the DL PRS transmitted from the neighboring TRPs and reports the measurements or report the calibration results to the LMF;

For methods 4, it may require the enhancement to configure or trigger the reference UEs to measure and report the measurements to LMF;

In addition, there are suggestions of consulting with RAN4 on the feasibility/capability of the estimation/calibration/compensation of Rx/Tx timing delays.

**Note:** It seems that the terms “mitigation, estimation, compensation, calibration, elimination, etc.” are used in the contribution for the mitigation for UE/gNB Rx/Tx timing delays. To avoid confusion, it might be better for us to use the same terminology in our discussion, e.g.,

* “Estimation of Rx/Tx timing delays”: It means the estimation of the values of the UE/gNB Rx/Tx timing delays for supporting the mitigation of Rx/Tx timing delays;
* “Calibration/Compensation of Rx/Tx timing delays”: It means the use of the estimated/known Rx/Tx timing delay values to remove the impact of the UE/gNB Rx/Tx timing delays;
* “Cancellation of Rx/Tx timing delays”: It means the cancellation of the impact of the UE/gNB Rx/Tx timing delays on the measurements or position solutions without the necessity of estimating the values of Rx/Tx timing delays.
* “Mitigation of Rx/Tx timing delays”: It is a general term, which means the mitigation of the impact of Rx/Tx timing delays on the timing measurements and position solution with any of potential approaches.

Comments on above suggestion

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| **Company** | **Comments** |
| Huawei/HiSilicon | Just to clarify our understanding   * “Estimation” is delay estimate per TRP/UE chain * “Calibration/Compensation” is per TRP/UE chain based on “estimation” * “Cancellation” is per TRP/UE chain pair * “Mitigation” can be through either “Calibration” or “Cancelation” |
| FL | To HW’s comments, yes, that is basically what I am thinking. |
| ZTE | Ok with the understanding. |
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## Estimation of UE/gNB Tx/Rx timing errors based on existing UE/TRP measurements

FL Comments

UE/gNB TX/RX timing errors may be estimated/calibrated by the use of the existing timing measurements (e.g., RSTD, RTOA, UE/gNB Rx-Tx time differences) (e.g., [1][2]) and the combination of the existing timing and angle measurements (e.g., RSTD, UE Rx-Tx time difference, AOA/AOD) (e.g., [1] [2][12]).

Proposal 2-1

* + UE should support reporting multiple measurements (including RSTD, RSRP, UE Rx-Tx time difference measurements) with timestamps derived on the same set of DL PRS resources to LMF in a single measurement report
  + FFS: details of signalling and procedures

Comments

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| **Company** | **Comments** |
| MTK | 1, the wording of the proposals maybe confusing. It reads like we want to include RSTD RSTP UE RX-TX time difference measurements together in a single report. We think the intention should be for **each** measurement **method**, the conducted measurement**s** within a period of time can be reported with the corresponding time-stamp for each measurement  2, if there is NO average among measurements on multiple occasions (one measurement on one occasion), then for each measurement in a single occasion, as it is tagged with the corresponding time-stamp, or the differential time-stamp from previous time-stamp (the first measurement gives absolute time-stamp and second measurement gives relative time-stamp from the first one), is okay for us |
| vivo | Not support. We don't understand the purpose of Propsal2-1 here, since the Rel-16 spec already supports UE reporting RSRP along with RSTD or Rx-Tx measurement. If the proposal is for reporting { RSTD, RSRP, UE Rx-Tx }together, we don’t think it can mitigate the Rx/Tx timing error. |
| Huawei/HiSilicon | Support, but the wording “UE should support” is not typically used in the WI.  In our understanding, the proposal is to allow UE to report measurements in multiple measurement occasions in the single report.  Perhaps the Proposal can be reformulated as   * + Support a UE to report multiple measurements of the same type (including RSTD, RSRP, UE Rx-Tx time difference measurements) with timestamps derived on different periodic occasions for the same set of DL PRS resources to LMF in a single measurement report   + FFS: details of signalling and procedures |
| CMCC | This proposal seems ambiguous to us.  To our understanding, the mitigation method and the associated measurement reporting should be positioning method specific, generally proposing that multiple measurements should be reported is quite unclear to us how would it work. |
| CATT | Support. |
| FL | For MTK and vivo’s comments, the motivation is that multiple companies have proposed to use the combination of the measurements for the estimation of the timing errors. Yes, Rel-16 already supports reporting the combination of the measurements. However, for the estimation of Rx/Tx errors, it might be desirable to use measurements measured with the same set of resources and at the same time (or time duration). I assume that is why some companies proposed to further enhancement of the measurement reporting.  For HW’s comment, I would say the modification helps the clarify the intention of the proposal.  For CMCC’s comment, I assume LMF may request the multiple measurements for supporting a positioning method for a UE. For Rel-17, I assume we may also further discuss whether LMF can request extra measurements for supporting both positioning of a UE, or also the estimation of the Tx/Rx timing errors. |
| Qualcomm | I was also confused by this proposal initially, but the reply from HW and FL clarified.  Indeed, this does not try to include in a single report different type of measurements (except those already existing in Rel-16, i.e. Timing & RSRP exists in a signle report). It tries to say that, in a single measurement report, e.g. in the RTT report, include the Rx-Tx/RSRP measurements that may be derived across multiple time-stamps. As a simple example, consider a toy example where there is just a single gNB with a single PRS resource configured, and the Measurement reporting happens every 10 PRS instances, then this proposal will enable that a UE can send 10 Rx-Tx measurements within a single reporting.  We think this can be useful for several reasons:   * For MRTT, it can help the LMF better “match” the reported UE Rx-Tx with the reported gNB Rx-Tx. In the current specification, the measurements may be non-aligned, resulting into making the timing errors due to different time-stamps prominent * When the UE sends 2 reports, e.g., an RTT and a TDOA report, with this proposal, both of them will have measurements derived on the same time-stamps, enabling better combination of those, * When a UE sends a DL-TDOA report, and a gNB sends an UL-TDOA report, both reports will have measurements derived on the same time-stamps, enabling combination at the LMF of those methods * It can help the LMF track non-idealities related to time-drifts at the UE or the gNB side   However, what is missing is to have to do the same enhancement from the gNB side which seems to be shown in the proposal below; we think both should be treated jointly; it wouldn’t make sense to agree on the first and not the 2nd. |
| Nokia/NSB | What is the specification impact of this proposal? Looking at the LPP sepc the IE nr-DL-PRS-RSRP-Result-r16 is already supported as part of DL-TDOA and multi-RTT (both of which also support time stamping). If this is related to multiple measurements being made within a single report then can the proponents clarify how that helps to alleviate Rx/Tx timing delays? |
| Ericsson | The current formulation of the proposal is confusing. We suggest the following revised proposal:  “Reporting multiple timestamped measurement occasions in a single measurement report from UE to LMF with all measurements being performed on the same DL PRS resources is supported in NR Rel-17”  Similar to the second comment from MTK, we think there should be NO averaging among the measurements on multiple occasions here. We suggest to study signalling and procedures for controlling how the UE averages and reports over multiple PRS occasions. |
| Fraunhofer | The proposal is early at this stage, the relevance to timing delays mitigation is subject to the latter proposals which are still under discussion. |
| Apple | Clarification is needed. We understand different intentions from the proposal (at least 2): 1-multiple measurements are associated with the same PRS reception and so the same time stamp (if this is the case we are OK to further discuss). 2- A single measurement report carries multiple reports where each report is associated with its time stamp (if this is the intention we like to know the group delays can be estimated, as Nokia/NSB mentioned). |
| China Telecom | We support the proposal with HW’s clarification. |
| OPPO | We don’t see much benefit to report multiple measurements of the same type in one report.  On the other hand, report multiple meaurements of different types will be useful. I mean it is benefical to to support the joint reporting of timing-based and angle-based measurement.  In DL-TDoA measurement reporting specified in Rel-16, the UE reports RSTD measurement and can also report the RSRP measurement of DL PRS resources used to measure the RSTD. However, the measurement results for these two types of positioning may not be suitable for joint processing. On potential issue is that the RSTD is measured from one DL PRS resource set while a valid RSRP should be measured from only one DL PRS resource. For better performance, the joint measurement and reporting of timing based and angle based positioning per DL PRS resource is preferred. Thus, Proposal 2-1 is suggesting to ensure the measurements on the same DL PRS resources.  As for the spec impact, we see that the meausruement for different positioning method should be basd on the same PRS resource, which is not mandatory in Rel-16 spec.  In summary, We suggest to revise Proposal 2-1 for the joint reporting of timing-based and angle-based measurement   * + . Support UE ~~should~~ to ~~support reporting~~ report multiple measurements of different types (e.g., including RSTD, RSRP, UE Rx-Tx time difference measurements) with timestamps derived on the same set of DL PRS resources to LMF in a single measurement report   + FFS: details of signalling and procedures |
| FL | Although LPP supports including multiple types of measurements in one single repor with each measurement having its own timestamp, there is currently no requirement to enforce the DL and UL measurements are associated with the same set of DL PRS and UL SRS resources and the same timesteps, which could potentially cause a problem when the measurements are combined for the purpose of positioning (e.g., Multi-RTT) as mentioned in QC’s comments or for for the estimation of the Rx/Tx timing errors (e.g., combination of RSTD, UE/gNB Rx-Tx time difference). The intention of the proposal might be cleaer if Proposal 2-1 and Proposal 2-2 are discussed together, as suggested by Qualcomm.  How about we combine Proposal 2-1 and Proposal 2-2 as follows?   * Support enabling:   + a UE to report multiple measurements (including RSTD, DL RSRP, UE Rx-Tx time difference measurements) in a single measurement report to LMF, and   + a TRP to report multiple measurements (including RTOA, UL RSRP, gNB Rx-Tx time difference measurements) in single measurement report to LMF, and   + the UE and TRP’s measurements in the reports are measured from the same set of DL PRS and UL SRS resources with the timestamps derived from the DL PRS and UL SRS occasions within the same measurement window |
| vivo 2 | We can understand the intention of FL, HW, and QC from the discussion and the updated proposal. But this AI is for mitigating RxTx Timing delays, we can’t identify the benefits clearly of this updated proposal sub-bullet 1and 3 for mitigating RxTx Timing delays.  1) one is multiple reporting with different stamps for a measurement report, we also want to confirm its significance for mitigating or estimating the group delays.  3) another is “the same set of DL PRS resources” for different methods, we think it only can be used to combine the different methods and can’t mitigate the Rx/Tx timing error as Rx/Tx timing error exists in both TDOA and Multi-RTT. |
| ZTE | From the comments above, we understand that the intention of this proposal is to report multiple timestamped measurements from different occasions in a single report, where the report includes the same type of measurement. We agree with Fraunhofer, we can come back later until the definition of timing delays and relevant enhancements are clear. |
| LG | We are fine with the FL’s modified proposal in principle. We also think that RSTD and Rx-Tx time difference measurements obtained within the strictly similar time would be required to mitigate timing error. |
| Huawei/HiSilicon | Regarding the updated proposal from the FL:  First bullet: we are not clear about the scope. Does it include both cases for multiple measurements of the same type, and multiple measurements of different types that are derived based on the same resource (set)?  Second bullet: In our view, TRP to report multiple measurement each associated with one occasion is already supported in NRPPa. Companies want it to be more specific, we can be fine if the proposal regarding AoA ambiguity in ePos-02 is treated in the same way.  Third bullet: the relationship with the first two bullets is not clear. We understand it is more of a clarification on the first two bullets, instead of a parallel proposal. Can the FL clarify? |
| Ericsson | We support the FL second proposal, but we would like further clarification. Our understanding of the proposal is illustrated below. In some cases, it would be good that the instance contain only one PRS occasion, so we propose that there could be a way to request measurements based on single occasions.  Diagram  Description automatically generated with medium confidence  **Revised proposal:**  **support enabling**   * **a UE to report multiple measurement intstances (of RSTD, DL RSRP, UE or Rx-Tx time difference measurements) in a single measurement report to LMF, and** * **a TRP to report multiple measurement instances (of RTOA, UL RSRP, or gNB Rx-Tx time difference measurements) in a single measurement report to LMF, and** * **Each measurement instance is reported with its own timestamp reflecting its measurement time window** * **FFS: the measurement instance can be configured to include only one PRS occasion** |
| Lenovo,Motorola Mobility | Supportive of the intention of the updated proposal, although the key difference of the proposed enhancement of reporting the timestamp associated with a PRS/SRS occassion vs current Rel-16 support of collecting multiple types of measurements in a single report with each measurement having its own timestamp should be made clear. Support Ericsson’s updated proposal. |
| FL | For vivo’s comment, ideally we should avoid different stamps. But, since the measurement is done within a window, the reports from UE and TRP may not have the same timestamps. The intention to have the same set of DL PRS resources is that there can be different Tx timing errors for different DL PRS resources (it may be more clear to “the DL PRS resources associated with the same Tx TEG” once we have the consensus to use the term TEG”. It may be fine to not explicitly mention it, since the DL/UL resources are configured by the network.  For HW’s comment, my consideration is to allow multiple measurements of the different types (e.g., multiple measurements of both RSTD and UE Rx-Tx time difference). The 3rd bullet is a condition on the measurement report for both 1st and 2nd bullet. The structure may need to be modified if that is not clear.  For Ericsson’s suggestion of modification, it looks fine to me with the following changes. Here I assume the network may confugre the measurement time window for the measurements;  **Support enabling**   * **a UE to report multiple measurement intstances (of RSTD, DL RSRP, UE or Rx-Tx time difference measurements) in a single measurement report to LMF, and** * **a TRP to report multiple measurement instances (of RTOA, UL RSRP, or gNB Rx-Tx time difference measurements) in a single measurement report to LMF, and** * **Each measurement instance is reported with its own timestamp within the configured measurement time window** * **FFS: the measurement instance can be configured to include only one PRS occasion** |

Proposal 2-1 (Revision 1)

* Support enabling
  + a UE to report multiple measurement intstances (of RSTD, DL RSRP, UE or Rx-Tx time difference measurements) in a single measurement report to LMF, and
  + a TRP to report multiple measurement instances (of RTOA, UL RSRP, or gNB Rx-Tx time difference measurements) in a single measurement report to LMF, and
  + Each measurement instance is reported with its own timestamp within a [configured] measurement time window
* FFS: the measurement instance can be configured to include only one PRS occasion
* FFS: details of signalling and procedures

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| **Company** | **Comments** |
| Nokia/NSB | We are not strongly against this type of proposal but trying to understand how it fits into the scope of this AI. If agreed how does this allow timing errors to be mitigated? If I follow the discussion above correctly then this just make it “easier” for the LMF to see measurements that are made with the same resources. But a smart implementation of Rel-16 would already be able to do this, no? |
| FL | The proposal is tightly related to the method of using both gNB and UE measurements for the estimation of the timing errors. In this case, there is a need for matching the measurements provided by the UE and the measurements provided by the gNB. It also helps Multi-RTT positioning, where it is desirable that UE/gNB Rx-Tx time difference measurements are matched and obtained in the same measurement window. |
| ZTE | 1. From the proposal we can not distinguish that, whether a single measurement report contains only RSTD measurements/only DL RSRP measurements, or, a single measurement report contains RSTD+RSRP+Rx-Tx time difference measurement. 2. Does a PRS occasion means a PRS resource or a time occasion of transmitting/receiving PRS? 3. What is the definition of single measurement report , does it mean “ProvideLocationInformation” message in LPP and “ MEASUREMENT RESPONSE” message in NRPPa?   With these questions above,we have similar concerns as Nokia and we are not sure the benefit of this. |
| MTK | 1, the wording reads like that the measurement results taken in different time instance **for each** measurement type can be merged into a single report. Also the measurement results taken in different time instance **for several** measurement types can also be merged together into a single report.  We don’t understand how the combination of RSTD and UE RX-TX time difference can help solve the timing delay. And we think that a single report may just consider a single measurement type, with multiple time-stamps. And the measurement results in different time instance **are not averaged**, because the timing delays would be changing with time |
| vivo | Sorry for we have the same understanding as Nokia and MTK, we don’t know how to mitigate or estimate the timing errors with the above information. For our method in 2.4, it only needs to configure smaller periodicity for reference UE, then the timing error estimated by reference UE can be compensated to other UE. Or the proposal means UE should not report the average or the filtered result of multiple measurements?  Besides, what is the spec impact? |
| Huawei/HiSilicon | In our understanding, for the TRP to report multiple measurement instances, it is already supported in spec, and if we want to make it clear, other features that face the same issue deserve to be treated equally.  In addition, for the third sub-bullet under the first bullet, we are not sure what the “configured measurement window” is, and suggest to have FFS on that.  In summary, we are OK with the following modification. Proposal 2-1 (Revision 1)  * Support enabling   + a UE to report multiple measurement intstances (of RSTD, DL RSRP, UE or Rx-Tx time difference measurements) in a single measurement report to LMF, and   + a TRP to report multiple measurement instances (of RTOA, UL RSRP, or gNB Rx-Tx time difference measurements) in a single measurement report to LMF, and   + Each measurement instance is reported with its own timestamp ~~within a [configured] measurement time window~~     - FFS: The measurement instances are within a [configured] measurement time window * FFS: the measurement instance can be configured to include only one PRS occasion * FFS: details of signalling and procedures |
| OPPO | We are ok with the 1st and 2nd sub-bullet of Bullet#1 if they are intended to report measurement results of the different types. For this case   * we should add a restriction that these measurement results are based on the same resource(s). * The 2rd sub-bullet is not needed   If multiple results are only the multiple instants of the same type, as some comments said, they are used by LMF to mach some results that they are closed enough in time domain   * For the three examples given by QC’s comment, when the measuremnts are based on different RS resources, we don’t think matching some results that are closed in the time domain can offer any gain. We cannot enfore UE to use the same RS resource(s) for different reporting that are associated with different positioning methods * Even in this case, the measurement time window is not needed as well since it is up to LMF how to match the measurement results from different reporting. Moreover, when UE/TRP are doing measurement X for one positioning method A, it does not know when the other meansuremt Y for positioning method B were/will be done, where LMF will matche measurement results Y and X at some later time. Thus, adding a window for the reporting does not facilitate LMF |
| CATT | Support. In our understanding, this proposal is one kind of enhancement to measurements. If each measurement instance among multiple measurement instances in a single measurement report is reported with its own timestamp within a short measurement time window, it will help LMF to track and compensate the timing delay errors based on such enhancements, especially the timing delays related to time drifts. |
| LG | We are supportive of the FL’s proposal. In addition, we think the third bullet is also important. The [configured] measurement time window is necessary to attain the timing measurements within in a same time duration to accurately track and compensate timing errors. |
| Fraunhofer | We have similar views as Nokia, MTK and vivo. If the motivation is allowing the LMF to compensate timing delay variations between the multiple measurement instances then there is additional information required which is subject to the discussion in section 3. |
| Apple | Similar view as Nokia and some other companies. In addition, if for example for m-RTT the UE Rx-Tx and gNB Rx-Tx are not associated with the proper PRS and SRS, then there is a problem with the m-RTT technique that should be resolved as a CR in Rel-16. |
| Ericsson | Our understanding is that this proposal is to mitigate Rx/Tx time delays that drift over time. So the proposal is in scope of the WID.  Based on the comments above, we think it is good to explicitly clarify whether   1. a single report may consist of only a single measurement type, or 2. a single report may consist of different measurement types.   As suggested by Huawei, we can have further discussion on ‘measurement time window’. So we are fine to have the ‘measurement time window’ in an FFS.  The 2nd bullet only refers to ‘one PRS occasion’. But the proposal now includes both UE measurements and TRP measurements. Hence, we suggest to revise the 2nd bullet to include ‘one SRS occasion’ as well. Please see suggested change below:   * Support enabling   + a UE to report multiple measurement intstances (of RSTD, DL RSRP, UE or Rx-Tx time difference measurements) in a single measurement report to LMF, and   + a TRP to report multiple measurement instances (of RTOA, UL RSRP, or gNB Rx-Tx time difference measurements) in a single measurement report to LMF, and   + Each measurement instance is reported with its own timestamp ~~within a [configured] measurement time window~~     - FFS: The measurement instances are within a [configured] measurement time window * FFS: the measurement instance can be configured to include only one PRS occasion or one SRS occasion. * FFS: details of signalling and procedures |
| FL | For ZTE’s comments:  1. Rel-16 already supports a single measurement report contains RSTD and/or DL RSRP, and/or measurements, Rx-Tx time difference measurement in a single report;  2. “The configured **measurement time occasions**” is already used in TS 38.215 for SRS-RSRP. I assume a PRS occasion can be considered as a time occasion of transmitting/receiving PRS. We may consider the following modification:   * the measurement instance can be configured to include only one PRS measurement time occasion   3. Single measurement report means a “ProvideLocationInformation” message in LPP, or a “ MEASUREMENT RESPONSE” message in NRPPa in my view.  For MTK’s comments:  1. To resolve the Rx/Tx time errors, my understanding is that there is a need to combine the measurements from UE sides and gNB side. The purpose of the proposal is to support the matching of the measurements from UE and gNB (including the beam ID and the time instances) for calculating the timing delay, but not based on UE’s measurements (RSTD+UE Rx-Tx time difference). Rel-16 already support a single report to report a single measurement type with multiple time-stamps in my view. Whether the measurement results in different time instance are averaged or not is up to implementation in Rel-16.  The “FFS: the measurement instance can be configured to include only one PRS occasion” has take MTK’s concern of “not averaged” into consideration.  For vivo’s comments:  1. About how to mitigate or estimate the timing errors with the UE/gNB measurements were discussed in previous meetings, e.g., (QC’s R1-2006810, MTK’s R1-2006194). The proposed enhancements can be used, but not limited to a normal UE or reference UE (if ref. UE is introduced). Above whether UE should not report the averaged or non-averaged needs further discussion (see also my response to MTK). The impact on the spec is “FFS”. Some companies may even consider no impact on the specs, but some companies consider there is a need, at least, some clarification, such as the reported values is “averaged” or “non-averaged” as mentioned in vivo’s comments.  For HW’s comments:  Some companies may consider TRP to already report multiple measurement instances is already supported in spec, and companies may not have the same view. As HW’s mentioned, we should make it clear for this and other features that face the same issue deserve to be treated equally. For the suggestion to include the “configured measurement window” in bracket, this is a reasonable suggestion to allow companies to have more time to consider it.    For OPPO’s comments:  I assume there is a need for the LMF to use the measurement results from the same resource(s). However, my understanding from the received comments is that this does not need to be included in the proposal for at least two considerations: a) LMF is responsible for the configuration resources, but do not know which resources can be measured by UE/TRP and b) UE/TPR do not know which measurements are useful by the LMF to mitigating timing errors. It would be easier for UE/TRP to report all of the measurements that UE/TRP decide to report, and let LMF to pick the measurements for the calculation of the Rx/Tx timing errors as OPPO also mentioned;  For measurement window, we can include in bracket, as also suggested by HW.  For LG’s comment, I understand the measurements should be obtained by the same time window. Based on the comments from OPPO and HW, let us keep it in bracket for now for further discussion.  For Fraunhofer’s comments, please see my response to NOK, MTK and vivo on the motivation of the proposal.  For Apple’s comment, yes, there is need that the measurements are associated with the proper PRS and SRS. That is one of the main reasons that the timestamp and time window are mentioned in the proposal. The discussion here is not limited to multi-RTT, but the calibration of Rx and Tx timing errors based the measurements from (e.g., RSTD, and UE/gNB Rx-Tx time difference).  For Ericsson’s comment, yes, we need to add SRS occasion.  The updated proposal is as follows for further discussion. Proposal 2-1 (Revision 1)  * Support enabling   + a UE to report multiple measurement instances (of RSTD, DL RSRP, UE or Rx-Tx time difference measurements) in a single measurement report to LMF, and   + a TRP to report multiple measurement instances (of RTOA, UL RSRP, or gNB Rx-Tx time difference measurements) in a single measurement report to LMF, and   + Each measurement instance is reported with its own timestamp ~~within a [configured] measurement time window~~     - FFS: The measurement instances are within a [configured] measurement time window * FFS: the measurement instance can be configured to include only one PRS measurement time occasion, or one SRS measurement time occasion * FFS: details of signalling and procedures |
| Huawei/HiSilicon | We support the change of Proposal 2-1 (Revision 1) from the FL. |
| CATT | Support the updated proposal 2-1 (Revision 1) from FL above.  We share the same view with Ericsson that SRS occasion is also needed in the proposal 2-1. |
| OPPO | We are fine with FL’s new update of Proposal 2-1 (Revision 1) |
| CMCC | We are fine with the FL’s revised proposal.  By going through companies’ comments and FL’s clarification, this proposal seems to estimate and mitigate the gNB/UE Rx/Tx timing delays in two possible ways. First of all, it is to mitigate the timing errors that drifted over time by reporting multiple measurement instances of a single measurement type within [a configured measurement time window], from this perspective, it is OK to us. On the other hand, it is to support the matching of the measurements from UE and gNB in order to calculate the timing delay more precisely. In such a case, different mitigation methods may refer to different reporting contents, which can be configured by LMF. For instance, if we consider using a reference UE to mitigate the gNB Tx timing errors for DL-TDOA, it can be solved by reporting multiple measurement instances of a single type (i.e., RSTD); if we consider using DL-TDOA+UL-TDOA to eliminate the impact of gNB Rx/Tx timing errors, the UE/TRP should report multiple measurement instances of different types (i.e., RSTD and RTOA), am I understand correctly, are we on the same page?  In addition, **one more typo** of the revised FL’s proposal, for the first bullet, it should be “or UE Rx-Tx time difference”, not “UE or Rx-Tx time difference”. |
| MTK | Based on FL and HW comments:  FL: The purpose of the proposal is to support the matching of the measurements from UE and gNB (including the beam ID and the time instances) for calculating the timing delay, **but not based on UE’s measurements (RSTD+UE Rx-Tx time difference)**  **Rel-16 already support a single report to report a single measurement type with multiple time-stamps in my view**. **Whether the measurement results in different time instance are averaged or not is up to implementation** **in Rel-16**  HW: In our understanding, **for the TRP to report multiple measurement instances, it is already supported in spec**, and if we want to make it clear, other features that face the same issue deserve to be treated equally  Then it seems that for the 3 main bullets in proposal 2-1 has been supported in Rel-16, So what are the key differences we may pursue? We think it should be that,  1, no average on different occasions and the measurement result in each occasion is tagged with its own time stamp  So we think the first FFS term should be more explicit as follows, and we propose the following revision   * Support enabling   + a UE to report multiple measurement instances (of RSTD, DL RSRP, UE or Rx-Tx time difference measurements) in a single measurement report to LMF, and   + a TRP to report multiple measurement instances (of RTOA, UL RSRP, or gNB Rx-Tx time difference measurements) in a single measurement report to LMF, and   + Each measurement instance is reported with its own timestamp ~~within a [configured] measurement time window~~     - Each measurement instance can be configured with a number of PRS measurement time occasions, or a number of SRS measurement time occasions, where “a number” includes the value of 1     - FFS: The measurement instances are within a [configured] measurement time window * ~~FFS: the measurement instance can be configured to include only one PRS measurement time occasion, or one SRS measurement time occasion~~ * FFS: the report indicates the RX and/or TX TEG, if TEG is defined * FFS: details of signalling and procedures |
| China Telecom | We support the proposal with FL’s update. |
| vivo | In general, we can agree with the proposal first.  But we think RAN4 should evaluate the drift rate of Rx/Tx timing error (just like the frequency error minimum requirement), then we can know which period of MR( measurement report) or how many MOs are needed to be reported for our requirement. In other words, when the periodicity of MR is small(for example 10ms), it may enough to compensate Rx/Tx timing error without using multiple instances.   |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 6.5.1.Minimum requirement for *BS type 1-C* and *BS type 1-H* For *BS type 1-C* and *BS type* 1-H, the modulated carrier frequency of each NR carrier configured by the BS shall be accurate to within the accuracy range given in table 6.5.1.2-1 observed over 1 ms.  The frequency error requirement for NB-IoT are specified in TS 36.104 [13] clause 6.5.1.  Table 6.5.1.2-1: Frequency error minimum requirement   |  |  | | --- | --- | | BS class | Accuracy | | Wide Area BS | ±0.05 ppm | | Medium Range BS | ±0.1 ppm | | Local Area BS | ±0.1 ppm | | |
| LG | We are OK with the modified proposal from FL |
| FL | For CMCC’s comments:  I assume the main benefit of proposed enhancement is to match the UE and gNB’s measurements is to support the estimations of the timing errors more precisely. The impact of drift of timing errors may depends on UE and gNB’s uncompensated timing errors. For example, if we assume the frequency error is ±0.1 ppm, then the change of the timing error can be as long as ±0.1(ppm)\*0.01(s)= ±1ns, or 30cm. Thus, the impact may not be ignored. Another issue to be considered is UE motion, which also makes it undesirable to use averaged measurements for a long duration.  For MTK’s comments:  I assume I understand the intention of the proposed changes. We may consider replaing “   * FFS: the measurement instance can be configured to include only one PRS measurement time occasion, or one SRS measurement time occasion   With the following   * For UE, each measurement instance can be configured with *N* PRS measurement time occasions   + FFS: *N (N>=1)* * For TRP, each measurement instance can be configured with *M* SRS measurement time occasions   + FFS: *M (M>=1)*   For vivo’s comments, yes, I assume RAN4 could be consulted for the impact of the drift rate of Rx/Tx timing error. The impact of frequency error may also be calculated roughly based on the current RAN4 requirements, as shown in my response to CMCC’s comment. |
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FL Comments

Based on the comments, it seems most companies are supportive to FL’s modified proposals. MTK has some additional suggestions.We may consider to change

* FFS: the measurement instance can be configured to include only one PRS measurement time occasion, or one SRS measurement time occasion

With

* For UE, each measurement instance can be configured with *N* PRS measurement time occasions
  + FFS: *N (including N=1)*
* For TRP, each measurement instance can be configured with *M* SRS measurement time occasions
  + FFS: *M (including M=1)*

Proposal 2-1 (Revision 2)

* Support enabling
  + a UE to report multiple measurement instances (of RSTD, DL RSRP, UE or Rx-Tx time difference measurements) in a single measurement report to LMF, and
  + a TRP to report multiple measurement instances (of RTOA, UL RSRP, or gNB Rx-Tx time difference measurements) in a single measurement report to LMF, and
  + Each measurement instance is reported with its own timestamp ~~within a [configured] measurement time window~~
    - FFS: The measurement instances are within a [configured] measurement time window
* FFS: the measurement instance can be configured to include only one PRS measurement time occasion, or one SRS measurement time occasion
* FFS: the indication of the RX and/or TX TEG, if Rx and/or Tx TEGs are defined
* FFS: details of signalling and procedures

Comments

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| **Company** | **Comments** |
| Nokia/NSB | We think the first two bullets still require some clarification as they are a bit confusing as we read them now. We should make it clear that the exisiting measurement to positioning technique mapping is not being changed (i.e., new measurements are not possible to be reported in a given technique just more of the same measurements). |
| CATT | Support |
| FL | For NOK’s comments:   1. It is unclear to me why we need to discuss the mapping of exisiting measurements to positioning technique here. 2. The proposal may have impact on the measurement reporting, e.g., measurement IEs if TEG is indicated. Thus, we have FFS: for details of signalling and procedures. |

### Proposal 2-1 (Revision 3)

* Support enabling
  + A UE to report multiple measurement instances (of RSTD, DL RSRP, UE or Rx-Tx time difference measurements) in a single measurement report to LMF, and
  + A TRP to report multiple measurement instances (of RTOA, UL RSRP, 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 PRS measurement time occasions
    - 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 and procedures
  + Note: A measurement instance refers to one or more measurements of the same or different types, which are obtained from the same DL PRS resources, or the same UL SRS resources[, within a certain time window].

FL Comments

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| **Company** | **Comments** |
| vivo | Firstly, we need to be clarified what ‘one PRS measurement time occasion’ is. Can it be regarded as ‘one period of PRS’ for periodical PRS? Or regarded as ‘one PRS sample’ defined in measurement period requirement by RAN4?  Secondly, for the 4th and 5th sub-bullet, we think ‘FFS’ should be added at the beginning to align with the descriptions in ‘Revision 2’, so that we can further study the feasibility of both ‘whether each measurement instance can be configured with N PRS measurement time occasions’ and ‘the value of N’ instead of ‘the value of N’ only.  Besides, for the 6th sub-bullet, ‘indication of the RX and/or TX TEG’ is the detail contained in the report, which seems to be independent of what we are talking about here.  Therefore, some modifications as following:   * Support enabling   + A UE to report multiple measurement instances (of RSTD, DL RSRP, UE or Rx-Tx time difference measurements) in a single measurement report to LMF, and   + A TRP to report multiple measurement instances (of RTOA, UL RSRP, 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 PRS measurement time occasions     - 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: the indication of the RX and/or TX TEG, if Rx and/or Tx TEGs are defined~~   + FFS: details of signalling and procedures |
| CATT | Support. We believe this enhancement to measurements can help LMF to track and compensate the timing delay errors, especially the timing delays related to UE motion or time drifts. |
| OPPO | Some questions for clarification  1. If N>1, is the result reported by a UE measurement instance the average of the measurements based on N PRS occasions or a selected one out of the measurements?  2. Similar comment is also applicable to the case M > 1  3. Does a single measurement report refer to “*TRP Measurement Result*” (TS 38.455 Section 9.2.3.7, i.e., *TrpMeasurementResult*) or *TrpMeasurementResultItem*? |
| ZTE | The proposal is still unclear to us. How can we understand the “ measurement instance”? Take DL-AoD measurement as an example, UE can support up to 8 DL-AOD measurements per TRP, in which each DL-AOD measurement is associated with its own time stamp. Do we expect that a DL-AOD measurement of one TRP corresponds to a “measurement instance”? If the answer is yes, what is the spec impact of subbullet 1 and 3? |
| Huawei/HiSilicon | OK. To ZTE, ideally, our understanding is that the 8 RSRPs for DL-AoD corresponds to a single measurement instance based on the 8 PRS resources associated with same Rx beam (single PRS burst/occasion within a periodicity). |
| LG | We are supportive of this proposal. Regarding the comment 1/2 from OPPO, our understanding is that the intention of the configured N PRS measurement time occasions is to use the measurement obtained for the configured time window by network. Normally, we expect that the UE/gNB may average the measurements instead of selecting one out of measurements to improve the measurement accuracy considering the noise. |
| FL | For vivo’s comments:   1. For ‘PRS measurement time occasion’, I would agree it would be better to have a clear definition, To avoid confusion, I would suggest use the term “*a single instance of the DL-PRS Resource Set*”, which we already defined in Rel-16. 2. For the comment of adding “FFS” to 4th and 5th sub-bullet, I think the main idea is to have each UE measurement instance can be configured with different number of PRS measurement time occasions, since the main intention is to support configurable number of number of PRS measurement time occasions with a measurement window. 3. For the comment to removing 6th bullet, I share the similar that it can be removed for now.  * Support enabling   + A UE to report multiple measurement instances (of RSTD, DL RSRP, UE or Rx-Tx time difference measurements) in a single measurement report to LMF, and   + A TRP to report multiple measurement instances (of RTOA, UL RSRP, 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   + Each UE measurement instance can be configured with N *instances of the DL-PRS Resource Set*     - FFS: N (including N=1)   + Each TRP measurement instance can be configured with M SRS measurement time occasions     - FFS: M (including M=1)   + FFS: details of signalling and procedures   For OPPO’s comments:   * If N>1, I assume it would be up to UE’s implementation on how to make the measurements from the N PRS occasions (e.g., measurement averaging, as commented by LG). This also applies to M>1 case. * I assume a single measurement report refer to a message that include all measurements results (e.g., MEASUREMENT RESPONSE in TS 38.455)   For ZTE and HW discussion on “measurement instance”:   * For this proposal, I assume the “measurement instance” can be simply considered as a group of measurement results that have the same timestamp in a measurement report. |
| Nokia/NSB | We still have some concern on the 4th and 5th sub-bullets. In Rel-16 (for DL positioning) the LMF sends the UE a responseTime when it asks for the measurements back. So this may change the way an LMF configures a UE for reporting quite a bit. As such we think it is better to involve RAN2 in the discussion before we make a firm decision. So suggest to make all of 4th and 5th sub-bullets FFS. |
| FL | For NOK’s comments:   * Yes, after we reach the agreement of the proposal, it would be better for us to send an LS to RAN2 to check their opinions. |
| ZTE | Agree with Nokia, it’ s too early to decide at this stage considering this would lead to large spec impact in RAN2. |
| Apple3 | Further questions for clarification: 1) What is added by the first 3 bullets on top of Rel-16, especially if multiple measurements belong to the same technique (e.g. multiple RSTD measurements corresponding to multiple PRS occasions)? In my current understanding, nothing! 2)In the 4th and 5th bullets, should it be respectively UE/gNB “ measurement REPORT instance”? If so, same question as my 1st question here. |
| LG | The understanding for the wording such as “measurement instance” and “measurement time occasions” of both PRS and SRS could be different, since there is no official definition. For the revised wording for PRS measurement time occasions, that is, “a instances of the DL-PRS Resource Set”, it may mean the PRS measurement time within one period based on TS 38.214. To avoid ambiguity, we suggest to add “one period” for both PRS and SRS. For the “measurement instance”, our understanding is aligned with the FL’s comment, but we would like to suggest to add the definition (mentioned by FL) as a note to avoid ambiguity. |
| Ericsson | Ok. We are also ok with Nokia/NSB and ZTE comments regarding adding FFS to sub-bullets 4 and 5. |
| FL | It seems a number of companies (vivo, NOK, ZTE, Ericsson) prefer to add “FFS” to sub-bullets 4 and 5. So, let us add “FFS” for now. I assume RAN1 may need to first make the decusion on whether to support the enhancements and then ask RAN2 to check their opinions  For Apple’s comments:   * If we read main bullets 1-3 separtly without considering sub-bullets for bullet 3 and the main bullets 4-5, then I would agree that it is already supported in Rel-16. But, bullets 4-5 are not supported in Rel-16.   For LG’s comments:   * I would agree that it is important to have the common understanding on “measurement instance”. Maybe we can add the following note” * Note: A measurement instance refers to one or more measurements, which are obtained from the same DL PRS resources, or the same UL SRS resources, within a certain time window. |
| Huawei/HiSilicon | Since vivo raised issue during the GTW session, we would like to clarify the understanding of the word “measurement”, which depending on the context, may be interpreted as one or multiple of the following   * Measurement type: the type of measurement, including those defined in TS 38.215 e.g. DL RSTD, DL PRS-RSRP, and those not defined in TS 38.215, e.g. TOA, CIR, PDP * Measurement value: the value for a measurement type, e.g. DL RSTD value, AoA value, (additional) path TOA value * Measurement action: the procedure (normally Rx) for the purpose of obtaining the measurement values from a single RS/channel sample. Each measurement action is carried out within a measurement time occasion.   If the understanding can be aligned, we think the correct way of understanding the last Note from the FL summay would be   * + Note: A measurement instance refers to one or more measurements types, which are obtained from the same DL PRS resources, or the same UL SRS resources, [within a certain time window]. |
| FL | For HW’s comments:   * In my view, a measurement here is a more general term, including at least both measurement type and value, etc. It seems there is no need to further list. If we want to specifically mention the measurement type, maybe can add the the measurements can be the same of different types.      * + Note: A measurement instance refers to one or more measurements of the same or different types, which are obtained from the same DL PRS resources, or the same UL SRS resources, [within a certain time window]. |

## TRP measurement enhancements

Proposal 2-2 (closed, merged with Proposal 2-1)

* + Support a TRP to report multiple measurements (including RTOA, AoA and gNB Rx-Tx time difference) with timestamps derived from the same set of UL SRS for positioning resources, in a single measurement report.
  + FFS: details of Signallin and procedures

Comments

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| **Company** | **Comments** |
| MTK | Similar to the above proposal 2-1, if no average among measurements across occasions is conducted, we are okay |
| vivo | In general, we are okay with the proposal as AoA method is not affected by the Rx/Tx Transmission delays and can provide high UE location accuracy. But we wonder about the intention about “the same set of UL SRS”. |
| Huawei/HiSilicon | Support in principle. In our understanding that the current NRPPa already supports the functionality, but neither stage-2 nor stage-3 is explicit on such an implementation.  We understand the intention of this proposal is the counterpart at TRP side to the UE side. |
| CMCC | Support of using the UL-AoA measurement to calibrate the impact of timing delays on the timing-based positioning methods. |
| CATT | Support. |
| Qualcomm | Support and should be agreed together with Proposal 2-1.  To Huawei: NRPPa description tends to be not very clear, and the fact that the Information Elements appear as if it is supported, it is a “gray” area, and should be formalized as we are doing for the UE’s report. |
| Nokia/NSB | Similar comments as on proposal 2-1. |
| Ericsson | We have a similar comment as in proposal 2-1. Suggest the following revision:  “Reporting multiple timestamped measurements occasions in a single measurement report from gNB to LMF with all measurements being performed on the same UL SRS resources is supported in NR Rel-17 ”  As proposals 2-1/2-2 are the UE/TRP counterparts, we suggest to discuss and agree them together. |
| Fraunhofer | Same as in proposal 2-1 |
| Apple | Similar comments to Proposal 2-1 |
| China Telecom | Support. |
| OPPO | Support 2-2 if it is for the joint reporting of timing-based and angle-based measurement. Suggest to modify the proposa as below   * + Support a TRP to report multiple measurements of different types (including RTOA, AoA and gNB Rx-Tx time difference) with timestamps derived from the same set of UL SRS for positioning resources, in a single measurement report.   + FFS: details of ignallin and procedures |
| ZTE | Similar comments as proposal 2-1. |
| Lenovo,Motorola Mobility | Same response as in 2-2 |
| FL | Based on the comments, Discussion of proposal 2-2 is merged with Proposal 2-1. |

## Estimation of gNB Tx/Rx timing errors based on DL PRS measurements from TRPs

FL Comments

gNB TX/RX timing errors may be estimated/calibrated based on the DL PRS measurements provided by TRPs (e.g., [3][8][12][17]).

Proposal 2-3

* Support the following mechanisms and Signalling for the estimation of the gNB Rx/Tx timing delays
  + enabling a TRP to measure DL PRS transmitted from other TRPs
  + enabling a TRP to report DL PRS measurements to LMF
  + FFS: the details of signaling, measurements, and procedures

Comments

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| **Company** | **Comments** |
| MTK | 1, we want to understand whether gNB can measure its own round trip timing delays (DAC to antenna and back to ADC). At UE side, we think it could be feasible. If each TRP can measure its own round trip timing delays, for example, sending a signal from baseband and measure the phase difference when received in baseband. Then there is no need to use this method  2, we can further check with RAN4 on the feasibility of round trip timing delays. We think the one side delay is very challenging, but the round trip delay measurement gets more chance to achieve for both gNB and UE side  3, That using another TRP to measure signals from other TRPs is to assume that the TRP locations are known. We wonder how precisely the locations can be determined? |
| Vivo | Not support. We have some concerns as follows:    Since current TRP/gNB is not allowed to measure PRS, once inter-TRP Rx/Tx timing delay is applied, all the gNBs/TRPs in a certain scenario are required to measure PRS, and transfer the measurement results. The impact on the spec is large.  Besides, since the panel of one TRP has a certain downward tilt angle which is assumed to be basically fixed, we are not sure whether an effective air interface connection can be established between the TRPs, especially the air interface connection of LOS.  In addition, if there are fixed obstructions among the TRPs which need to be calibrated, so that sufficient LOS connections cannot be ensured between these TRPs, and furthermore the Rx/Tx timing delay of these TRPs cannot be calibrated. Due to the fixed location of the TRPs and obstructions, these TRPs cannot always be calibrated.  . |
| Huawei/HiSilicon | We have some technical concerns on the procedure.  First, it should be common understanding that PRSs from different TRPs on the same layer are transmitted simultaneously, and this approach, however, seems to put some gNBs on listening mode on the time when PRS is supposed to transmit.  Second, this will increase hardware of the gNB for FDD bands, as gNB is not required to implement Rx chains on DL carriers.  Third, the PRS targeting coverage is optimized for the UE, e.g. via downtilt considering UE should be below gNB, but to allow gNB to properly hear the PRS will somehow require additional optimization for PRS transmission direction. |
| CMCC | Support.  As per HW’s concern, for the first understanding, we believe it is the case for the R16 periodic DL PRS; however, considering that in the SI phase, companies reached a consensus to specify the on-demand DL PRS, we think that their transmission occasions of different TRP would be different. One possible solution can be configuring the on-demand DL PRS in Flex resources among TRPs, the measurement then can be performed. Regarding the antenna down tilting of the TRP, we also think it may be a shortcoming of this solution; however, since the channel between TRPs are more likely to be LOS and quite ideal, the estimation and calibration performance would be ensured. |
| CATT | Support. |
| Qualcomm | I think Proposal 2-3 and 2-4 should be combined within an umbrella of a “reference device/node/entity” and leave it at that level at this meeting. It is the first meeting of the WI, and it seems that both proposals are trying to enable “calibration of the errors”. In Proposal 2-3 the assumption is that the gNB have known location (which is indeed true), and in Proposal 2-4, we just call it “UE with known location”. Note also that there are similar discussions in the other subagends. I think it is a great opportunity to acknowledge that procedures related to calibration is needed across all methods and not limit to “timing errors” in the subagenda, and “AoD“ in the 2nd and “AoA” in the 3rd.  Suggest to combine 2-3 and 2-4 as follows:  ***Specify procedural and Signalling enhancements to enable devices 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 signaling, the measurements, the parameters related to the Rx and Tx timing delays,*** * ***FFS: Device with the known location being a UE and/or a gNB***   To Huawei: The feature may eventually call it a UE, which can be “attached to the gNB” similar to IAB approach. |
| Ericsson | We do not support this proposal. We share similar concerns with vivo and Huawei. In addition, we think this proposal is essentially trying to specify mechanisms for performing radio sync over the air. Network sync errors were discussed in the SI phase but are not within the scope of this work item. Recall from the SI phase that this can be done proprietarily with no need for specification impact. |
| Apple | We share similar views with vivo on specification impact, but if majority thinks it’s ok to have a reference entity, then going with QC’s proposal is preferred (to combine 2-3 and 2-4) |
| OPPO | Can we treat the TRP(s) measuring DL PRS as some reference UE although they use different protocols to communicate with LMF? Thus, we share the similar view as QC |
| ZTE | We support the FL’s proposal.  To vivo, LOS connection between TRP is not necessary. The propagation time in the air will be canceled, please refer to our contribution.  To Huawei’s concern, TRP may reserve some time for listening, so UE will not receive the PRS during the reserved time. Regarding the antenna down tilting of the TRP, we agree this would be a problem. But this would have less impact on timing measurement than angle measurement.  To Ericsson, the measurement can also use for monitoring timing errors.  Agree with QC’s proposal. The discussion should be aligned across all subagendas. |
| FL | At least 4 companies (vivo, Huawei, Ericsson, Apple) have the similar concern on the proposed enhancement, i.e., it requires a TRP to measure the DL PRS from another TRP, which is not supported in the current specification and TRP implementation. Thus, the proposed enhancement may have significant impact on the specification and TRP implementation.  Suggest further email discussion to see if the opponents can be to convinced to adopt the proposed enhancement. |
| Qualcomm | To vivo, Huawei, Ericsson, Apple: it does NOT talk about TRPs; it talks about a “reference device”. We can discuss later what this device will. Even if the device is a UE, it can attached to a TRP, so a TRP will be measuring PRS from another TRP. The fact that a device measures PRS from TRPs, it does NOT mean it helps with network sync. It has to report RSTDs for this to happen. The purpose here is to help with Timing errors (gNB Rx, Tx, gnb Rx-Tx) and not with the time differences between gNBs. So, ***NO, this proposal is not done to solve the network sync problem***; as we have discussed, this is not supposed to be in scope. This proposal would enable to specific reference devices to help with Timing errors (gNB Rx-Tx), AoD/AoA (discussed in other agenda).  What if we add this disclaimer for companies to be more assured? Added one more clarification in the FFS, if it helps, not sure.  ***Specify procedural and Signalling enhancements to enable devices 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 signaling, the measurements, the parameters related to the Rx and Tx timing delays,*** * ***FFS: Device with the known location being a UE and/or a gNB, or a UE attached to a gNB, etc*** * ***Note: Using these enhancements for the purpose of network synchronization is NOT within the scope of the WI*** |
| Intel | We do not support the first bullet of the proposal and prefer to keep the calibration procedure of TRP/gNB up to implementation. We support the second bullet, in our view the specification should be extended with signalling of estimated gNB Rx/Tx timing delays to LMF. |

FL Comments

The discussion is closed. See Chairman’s note for the agreement.

## Mitigating UE/gNB Tx/Rx timing errors based on DL PRS measurements from reference UEs

FL Comments

UE/gNB TX/RX timing errors may be estimated/calibrated based on the DL PRS measurements provided by Ues at known locations (e.g., reference/calibration Ues) with differential techniques (e.g., [2][4][5][6][14][16])

Proposal 2-4

* Support the following mechanisms for the estimation and/or elimination of the gNB Rx/Tx timing delays:
  + Enable a UE with a known location to measure DL PRS and report the measurements (e.g., RSTD, UE Rx-Tx time difference, RSRP) to LMF;
  + Enable a UE with a known location to transmit SRS for positioning and enable the neighboring TRPs to measure and report the measurements (e.g., RTOA, gNB Rx-Tx time difference, AOA) associated with the UE to LMF;
  + FFS: the details of the signaling, the measurements, and the parameters related to the gNB Rx and Tx timing delays

Comments

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| **Company** | **Comments** |
| MTK | 1, we should first clarify whether each TRP can measure its own round trip timing delays  2, again, UE with a known location, how precisely the location can be determined? |
| Vivo | Support.  From our contribution, it can be observed that ‘reference UE’ based method can be used in differential method to assist calibration of the TRP Rx/Tx timing delay and provide high accuracy. For scenarios where few TRPs are deployed or LOS links are sufficient such as indoor factory scenarios, fewer ‘reference Ues’ can guarantee the accuracy of the estimation and bring less overhead. For scenarios where many TRPs are deployed or LOS links are insufficient such as Uma scenario, more ‘reference Ues’ may be needed, however, to a certain extent, the large overhead can be solved according to the mobility of the UE.  For the accuracy of reference UE location from MTK, the location of reference UE is precise, it can use the same way as TRP to obtain its location especially in InF scenario. |
| Huawei/HiSilicon | Support. We think that setting the reference device to a “UE” would maximize reuse of the existing framework. |
| CMCC | We are basically fine with the proposal.  In our views, enabling a reference UE with known location in the deployment, which is an RTK-like method, is feasible to assist the estimation and mitigation of the gNB Rx/Tx timing delay. One potential issue is that the propagation environment around the reference UE may have great impact on the estimation and calibration performance (e.g., enough LOS links are required), therefore the location of the reference UE should be carefully designed. |
| CATT | Support. |
| Qualcomm | I think Proposal 2-3 and 2-4 should be combined within an umbrella of a “reference device/node/entity” and leave it at that level at this meeting. It is the first meeting of the WI, and it seems that both proposals are trying to enable “calibration of the errors”. In Proposal 2-3 the assumption is that the gNB have known location (which is indeed true), and in Proposal 2-4, we just call it “UE with known location”. Note also that there are similar discussions in the other subagends. I think it is a great opportunity to acknowledge that procedures related to calibration is needed across all methods and not limit to “timing errors” in the subagenda, and “AoD“ in the 2nd and “AoA” in the 3rd.  Suggest to combine 2-3 and 2-4 as follows:  ***Specify procedural and Signalling enhancements to enable devices 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 signaling, the measurements, the parameters related to the Rx and Tx timing delays,*** * ***FFS: Device with the known location being a UE and/or a gNB***   To Huawei: The feature may eventually call it a UE, which can be “attached to the gNB” similar to IAB approach. |
| Nokia/NSB | We may be okay in principle but we should discuss this as part of the reference UE discussion happening in other Ais as well. |
| Ericsson | We wonder what is the specification impact for this (particularly the last FFS). In our understanding, a reference UE can use the current standards, and we don’t see need for further specification changes. |
| Fraunhofer | Support. Agree with Nokia. |
| Apple | Support |
| China Telecom | Support. And we can think it may be necessary to discuss in what condition a UE can be chosen as the ‘UE with a know location’. |
| Samsung | This proposal and together with above proposal 2-3 seem creating a “reference UE” and a “reference TRP”, respectively. Especially for the purpose of estimating the TRP side errors, so the question is that do we need both types of “reference”? Not sure how accurate of this “reference UE”, but I guess it should be no better than the fixed/planed located “reference TRP”.  Another aspect is that what the true spec impact here? A UE (whether its location is known or not) can always be triggred to do DL PRS measurement/report and/or UL SRS-pos transmission, maybe I missed some rules here so hope there could be some clarification. |
| OPPO | There may be two different approach use a reference UE  Approach 1:   * 1. determine the real position of the UE (non-3GPP)   2. transit the real positioning info to UE (non-3GPP)   3. UE does measurements (3GPP)   4. UE sends reports to LMF (3GPP)   5. LMF do the calculation (implementation, transparent to the spec)   Approach 2:   * 1. determine the real position of the UE (non-3GPP)   2. transit the real positioning info to LMF (non-3GPP)   3. UE does measurements (3GPP)   4. UE sends reporting to LMF (3GPP)   5. LMF do the calculation (implementation, transparent to the spec)   We think the proposal is aligned with Approach 1. The differences between the two approaches as below  1. Step 1.2 and 2.2. We think they all use non-3GPP mechanism  2. Step 1.4 need specification as UE need to report the real positioning info to LMF whereas Step 2.4 can reuse the current spec.  Thus, what’s the benefit of Approach 1 compared to Approach 2? Why cannot we use Approach 2 that has no spec impact. |
| ZTE | We have concerns about this. Firstly, We wonder whether this reference UE can move like a normal UE or just stays at a certain position. If it can move, then how does the gNB know its accurate location at different time? It’s hard to ensure that reference UE and normal UE are within the same coverage of multiple TRPs. If it’s fixed, the reference UE is just like another TRP. So, we think this can be merged into proposal 2-3, whether the reference can be a TRP or a UE can be discussed in following meetings. |
| LG | We have similar view with Ericsson. |
| Huawei/HiSilicon | To OPPO:  Our understanding is that 2.4 may be 3GPP compliant with the current specification, as first UE should not report its location along with the location. In addition, we think that the LPP session should only be instigated with the LCS request, in which case the calibration device may not have any corresponding LCS request, e.g. which entity is the location consumer? |
| Lenovo,Motorola Mobility | Support in principle, share Nokia’s view as to how to address the similar reference UE discussions in other Ais. |
| OPPO | Based on Huawei’s comment, I update the components of two approaches by adding the component “NW requests the reporting” ( the components are not listed to follow the real service procedures)  Approach 1:   * 1. determine the real position of the UE (non-3GPP)   2. transit the real positioning info to UE (non-3GPP)   3. UE does measurements (3GPP)   4. NW requests the reporting   5. UE sends reports to LMF (3GPP)   6. LMF do the calculation (implementation, transparent to the spec)   Approach 2:   * 1. determine the real position of the UE (non-3GPP)   2. transit the real positioning info to LMF (non-3GPP)   3. UE does measurements (3GPP)   4. NW requests the reporting   5. UE sends reporting to LMF (3GPP)   6. LMF do the calculation (implementation, transparent to the spec)   We think the proposal is aligned with Approach 1. The differences between the two approaches as below  1. Component 1.2 and 2.2. We think they all use non-3GPP mechanism  2. Component 1.5 need specification as UE need to report the real positioning info to LMF whereas Step 2.5 can reuse the current spec.  3. Component 1.4 and 2.4 is the same functionality, and they has the same impact on specification if there is any.  Thus, Approach 2 has no or less spec impact. |
| FL | My understanding is that in Rel-16 LMF may/can collect the information for the estimation and/or elimination of the gNB Rx/Tx timing delays from random positioning occasions triggered by LCS. But, Rel-16 does not support the mechanisms for LMF to explicitly request a UE to transmit SRS or receive DL PRS for the purpose of mitigating gNB Rx/Tx timing delays. We can further discuss the issue related to how to determine a UE is in a known location and what UE is qualified to be the reference UE etc. once we have the consensus to support the mechanisms.  For QC’s comment, I would suggest still having separate discussion of Proposal 2-3 and 2-4 even though they can be coverd in the same term of “reference device”. Proposal 2-3 requires a TRP to measure and report the DL PRS from another TRP, it has much larger impact on both TRP implementation and the signalling support (NPPa). Proposal 2-4 has basically no small impact on UE implementation, and small impact on the signalling. I would take the suggest of the wording changes from QC for the revision of the proposal.  For Nokia’s comment, I would suggest we start the discussion in this AI at least for the purpose of mitigating Rx/Tx timing errors. If there is any similar proposal in other AI, we can discuss the additional changes.  For ZTE’s comments, we assume there is no constraint on whether the UE is stationry or moving. It will be up to LMF’s implementation and algorithms on how to use the measurements from UE for mitigating the Rx/Tx timing errors. |

Proposal 2-4 (Revision 1)

* Specify procedural and Signalling enhancements to enable a UE 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 ignalling, the measurements, the parameters related to the Rx and Tx timing delays,

Comments

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| **Company** | **Comments** |
| Nokia/NSB | We support in principle this proposal. Also okay for us to change UE to (UE/TRP/node). We would also like to highlight the potential need for capability signalling for this type of device with known location. We are open to discussing those details later in the WI however. |
| ZTE | We would like to combine proposal 2-3 and 2-4 for discussion at this stage, the reference positioning entity can be UE or gNB. Additionally, we still have some concerns about the reference UE. The reasons are as follows:   1. If different Ues have different measurement error due to equipment differences, measurement error of the reference UE is not equal to that of the normal UE needed for positioning. Thus, new timing errors will be introduced rather than mitigated. 2. It’s hard to ensure that reference UE and normal UE are within the same coverage of multiple TRPs. 3. Compared with reference UE, a reference TRP may be more easy to implement. |
| Vivo | We prefer to modify as follows   * Specify procedural and Signalling enhancements to enable a UE 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 ignalling, the measurements, the parameters related to the Rx and Tx timing delays,   + FFS: reporting reference UE coordinate information to the LMF |
| Huawei/HiSilicon | We support this proposal, and OK to change UE to (UE/TRP/node) as well, which serves the baseline for further discussion. |
| OPPO | Some companies believe the solution based on reference TRP/UE can be based on implementation and has no spec impact. As shown by Approach 2 in our previous comment, it is possible to enable this functionality with spec change. Thus, it is premature to say we will specify something in this stage. Further discussions are needed |
| CATT | We support to introduce the reference UE/TRP in Rel-17. In GNSS domain, it is common to correct the positioning errors and provide high accuracy positioning services based on the reference station. The reference UE/TRP will play different roles for different positioning methods, e.g., timing delay error mitigation for time-based positioning method or antenna calibration for angle-based positioning method. |
| LG | We are supportive of introducing both of the reference UE and TRP, which is helpful to improve the positioning accuracy. |
| FL | For ZTE’s comments that different Ues have different measurement and different TRPs have different coverage, I assume it is open for discussion on how to make the method more reliable/accurate. In general, I think it can, and should be, handled by implementation algorithms when the LMF collects the information from the UE/TPRs.  For vivo’s comments to add “FFS: reporting reference UE coordinate information to the LMF”, I assume it can be covered in the previous FFS. But, it may also be fine to mention it specifically.  For OPPO’s comment, if reference TRP is included, as suggested by OPPO, then there will obviously the impact on the specification, since in current specification, TRP does not support DL PRS measurements. If only reference UE is considered, the impact to the specification could be much smaller in my view, which can be further discussed once we have the consensus to support the method.  For NOK/ZTE/HW/OPPO/CATT/LG’s comments to include both reference UE and TRP, I would suggest waiting for the responses from other companies. In the discussion of Proposal 2-3, some companies had already commented that they are not supportive to use reference TRP. |
| Apple | Support the proposal |
| Qualcomm | Not acceptable to us. Prefer to keep “reference device”. We can discuss later what this device will. Even if the device is a UE, it can attached to a TRP, so a TRP will be measuring PRS from another TRP. The fact that a device measures PRS from TRPs, it does NOT mean it helps with network sync. It has to report RSTDs for this to happen. The purpose here is to help with Timing errors (gNB Rx, Tx, gnb Rx-Tx) and not with the time differences between gNBs. So, ***NO, this proposal is not done to solve the network sync problem***; as we have discussed, this is not supposed to be in scope. This proposal would enable to specific reference devices to help with Timing errors (gNB Rx-Tx), AoD/AoA (discussed in other agenda).  What if we add this disclaimer for companies to be more assured? Added one more clarification in the FFS, if it helps, not sure.  ***Specify procedural and Signalling enhancements to enable devices 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 signaling, the measurements, the parameters related to the Rx and Tx timing delays,*** * ***FFS: Device with the known location being a UE and/or a gNB, or a UE attached to a gNB, etc***   ***Note: Using these enhancements for the purpose of network synchronization is NOT within the scope of the WI*** |
| Ericsson | We still have concerns over this proposal. The main bullet says ‘specify procedural and signalling enhancements’. But what is captured in the 1st and 2nd sub bullets are already possible in current specs. As commented by OPPO, we should start discussions with approaches that have no spec impact, and then identify what spec enhancements are needed. Hence, similar to OPPO comment, we also think that it is premature to have this agreement.  Furthermore, we are not ok with combining proposals 2-3 and 2-4. In proposal 2-3, measurement of DL-PRS by TRPs would have to be specified which would involve large specification impact. Hence, we prefer to discuss reference UE for the time being and identify the needed specification impact, if any. We prefer not to introduce reference devise or reference TRP into this proposal. |
| FL | I can understand QC’s comment to use “devices” instead of “UE”, and Ericsson comment of not merge Proposal 2-3 and Proposal 2-4.”  For Ericsson’s comment, I do not fully understand the suggestion to start discussions with approaches that have no spec impact. I assume whether a proposed approach has or has no spec impact can be identified during the discussion of the approach. Thus, it seems no need to limit the discussion starting from approach that has no impact of the specification.  Based on the comments, the suggestion is to modify the proposal as follows, where the device is FFS:   * Specify procedural and Signalling enhancements to enable a 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 ignalling, the measurements, the parameters related to the Rx and Tx timing delays,   + FFS: reporting reference UE coordinate information to the LMF   + FFS: Device with the known location being a UE and/or a gNB, or a UE attached to a gNB, etc * Note: Using these enhancements for the purpose of network synchronization is NOT within the scope of the WI |
| InterDigital | Thank you very much for the discussion. We support adding the FFS point “reporting reference UE coordinate information to the LMF”, and to reflect the FFS point, we propose to modify the proposal so that the known location of the UE is known by the LMF since in the original contribution, it was not clear who knows the location of the reference UE. We propose the following modification to the proposal.   * Specify procedural and Signalling enhancements to enable a device, whose location is know by the LMF,on 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 ignalling, the measurements, the parameters related to the Rx and Tx timing delays,   + FFS: reporting reference UE coordinate information to the LMF   + FFS: Device with the known location being a UE and/or a gNB, or a UE attached to a gNB, etc * Note: Using these enhancements for the purpose of network synchronization is NOT within the scope of the WI |
| FL | To InterDigital’s comments:  Not sure if I fully understand the intention of the modification of “device, whose location is known by the LMF”, since InterDigital also supports: “FFS: reporting reference UE coordinate information to the LMF”. This bullet is for the case when LMF does not have the location information of the UE, and thus need UE to report its coordinate information to the LMF. |
| CATT | Support updated proposal 2-4(Revision 1) from FL’s comments above.  We support the name of reference is changed from “UE” to “Device”, since maybe TRP can also be a reference for calibration of Timing errors. |
| InterDigital | For FL:  Thank you very much for the discussion and explanations. The reason behind our proposal is because it was not clear who knows the reference device’s location. The FFS indeed explains that the device may report to the LMF. In that case we assume that the LMF is the only entity that has the reference device’s location (i.e., if gNB is the reference device, the reference gNB does not know its own location). If we have the same understanding, it should be described explicitly in the proposal for clarity.  In addition, if “FFS: reporting reference UE coordinate information to the LMF” is the case where LMF does not have the location of the reference UE, since we have an additional FFS “FFS: Device with the known location being a UE and/or a gNB, or a UE attached to a gNB, etc”, it should be “FFS : how the LMF acquires the location of the reference device.”   * Specify procedural and Signalling enhancements to enable a device, whose location is known by the LMF, 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,   + FFS : how the LMF acquires the location of the reference device.   + FFS: Device with the known location being a UE and/or a gNB, or a UE attached to a gNB, etc * Note: Using these enhancements for the purpose of network synchronization is NOT within the scope of the WI |
| OPPO | FL said “I assume whether a proposed approach has or has no spec impact can be identified during the discussion of the approach.”. However, the current proposal is “specify procedural and …”. It means this proposal is not aligned with the above-mentioned comment from FL. We suggest to revise the proposal as below (Based on FL’s version)V   * Study and, if needed, Specify procedural and Signalling enhancements to enable a 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 signaling, the measurements, the parameters related to the Rx and Tx timing delays,   + FFS: reporting reference UE coordinate information to the LMF   + FFS: Device with the known location being a UE and/or a gNB, or a UE attached to a gNB, etc * Note: Using these enhancements for the purpose of network synchronization is NOT within the scope of the WI |
| CMCC | Regarding FL’s revised proposal, we have one thing to be clarified, are we excluding this particular case that a reference device can adopt the UE-based positioning, then its location is not necessarily known by the LMF? In such a case, the reference device can estimate the timing errors by itself and then reports the estimated errors to the LMF. |
| China Telecom | Support the proposal with FL’s update. |
| vivo | In general, we are okay with updated proposal 2-4(Revision 1) from FL’s comments.  But “a UE attached to a TRP” and the reply in QC(“Even if the device is a UE, it can attached to a TRP, so a TRP will be measuring PRS from another TRP” ) is unclear for us. Could the proponent clarify it more? |
| LG | We have a clarification question on a UE attached to a gNB. Does it means an IAB(Integrated Access Backhaul) node (it is composed of a MT and DU)? |
| FL | For InterDigital comments:  Shoud I assume the modificati of “FFS: the report of device coordinate information to the LMF if LMF does not have the information” address the concern on “who knows the reference device’s location”?  For OPPO’s comment:  My previous comment is main for the response to Ercisson’s comment that the discussions start with approaches that have no spec impact. For the proposal Proposal 2-4 under discussions, it seems clear that it will have the imact on the specs. Thus, it seems no need to add “Study and, if needed,” if my view.  For CMCC’s comment:,  I assume for UE-based case, it UE does not send its own position to LMF, then I assume LMF needs to send TRP positions to UE. Is that the suggestion?  It seems at least two companies have question on the UE attached to a gNB in FFS: bullet. We have not discuss what it means by “UE attached to a gNB”. Thus, I will put it into bracket I the revised version. |

Proposal 2-4 (Revision 2)

* Support enabling a 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;
  + FFS: the report of device coordinate information to the LMF if LMF does not have the information
  + FFS: the device with the known location being a UE and/or a gNB [, or a UE attached to a gNB]
* Note: RAN1 assumes using these enhancements for the purpose of network synchronization is NOT within the scope of the WI

Comments

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| **Company** | **Comments** |
| Nokia/NSB | We are okay with the proposal. It reads a bit more like a WID objective rather than an agreement though. Perhaps we should just remove “Specify procedural and signalling enhancements to” as it does not change the meaning. |
| CATT | Support. |
| Intel | We do not see additional specification impact on top of Rel-16 except “reference UE” term/concept. We think that decision should be made on reference UE/TRP/node first. |
| FL | I would agree with NOK’s comments. “Specify procedural and Signalling enhancements to” can be removed. |
| Huawei/HiSilicon | In general, we are fine with the suggestion. A small suggestion on the last “Note”, in which we prefer to add “RAN1 assumes using these enhancement…”. |
| FL | For Intel’s comments:   * It is unclear how we can first make the decision of the reference UE/TRP/node first. I assume we can first decide whether to support the functionalities and then determine the impact on the specs based on the agreement on which device can be used as the reference;   For HW’s comments:   * I cannot see the difference whether to add “RAN1 assumes”. So, I will added it in if companies consider it is needed. |

FL comments

The discussion was closed with the following agreement.

|  |
| --- |
| 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;   + 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 |

# Mitigation of Rx/TX timing delays

Submitted Proposals (general proposals for mitigating Rx/TX timing delays)

* (Huawei [R1-2100195](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100195.doc)) Proposal 2:
  + Support UE to report of the panel information for DL reception and UL transmission to LMF, and leave the network assisted/controlled panel selection up to Rel-17 MIMO WI.
* (Huawei [R1-2100195](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100195.doc)) Proposal 3:
  + Given the existing positioning calculation assistance data framework, resource-specific RTD and RTD drift rate should be low priority.
* (ZTE [R1-2100293](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100293.doc)) Proposal 2:
  + In order to mitigate the Tx/Rx timing delay for DL-TDOA/UL-TDOA positioning method, considering the following enhancements in Rel-17
    - The TRP should have capability to do mutual-calibration and feed back the Tx timing delay difference and Rx timing delay difference.
    - For UE based positioning, network should provide TRP-side Tx timing delay difference in assistance data.
    - Provide by network or report by UE to indicate whether UE uses the same RF chain to transmit or receive signals from different TRPs.
* (CATT [R1-2100385](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100385.doc)) Proposal 1:
  + For UE-based DL-TDOA positioning, one of the following methods can be used to help UE eliminate the influence of Tx timing delay and synchronization error of TRPs:
    - Method1: Provide UE the information of Tx timing delays of RF chains of the TRPs for transmitting DL-PRS, or the difference of the Tx timing delays of RF chains between TRPs. The time offset between TRP clocks needs also to be provided if the TRP clocks are not perfectly synchronized.
    - Method2: Provide UE the information of the time synchronization error at the Tx antennas between the TRPs.
* (CATT [R1-2100385](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100385.doc)) Proposal 2:
  + For UE-assisted DL-TDOA positioning, one of the following methods can be used to help LMF eliminate the influence of timing delay and synchronization error of TRPs:
    - Method1: Provide LMF the information of Tx timing delays of RF chains of the TRPs for transmitting DL-PRS, or the difference of the Tx timing delays of RF chains between TRPs. The time offset between TRP clocks needs also to be provided if the TRP clocks are not perfectly synchronized.
    - Method2: Provide LMF the information of the time synchronization error at the Tx antennas between the TRPs.
* (CATT [R1-2100385](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100385.doc)) Proposal 3:
  + For the UL-TDOA positioning, the following method can be used to help LMF eliminate the influence of UE timing delay error:
    - Provide LMF the Tx timing delays of RF chains of the UE for transmitting SRS-Pos, or the difference of the Tx timing delays of RF chains between UE Tx RF chain with index=m and index=n.
* (vivo [R1-2100445](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100445.doc)) Proposal 3:
  + To avoid Rx/Tx timing delay from affecting angle estimation for DL-AoD and UL-AoA method, support to limit to only one TXRU (or panel) used by the gNB for positioning.
* (vivo [R1-2100445](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100445.doc))Proposal 2
  + AoA-based RX/TX timing delay mitigating method should be considered as an alternative method to ‘reference UE’ based differential positioning method.
* (CAICT [R1-2100308](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100308.doc))Proposal 2:
  + Tx group delay needs to be sent to the receiver side.
* (Fraunhofer [R1-2101131](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101131.doc)) Proposal 1:
  + Enable Rx/Tx timing delays reporting dependent on the applied transmission/reception spatial filter.
* (Fraunhofer [R1-2101131](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101131.doc)) Proposal 2:
  + Enable reporting of TRD information from both UE and TRP, which includes at least:
    - TRP reports to the LMF Tx timing delay information on the beams used to transmit DL-PRS
    - UE reports to the LMF Tx timing delay information on the beams used to transmit SRS for positioning
    - LMF reports to the UE Tx timing delay information on the beams used to transmit DL-PRS in UE-based mode
* (MediaTek [R1-2101140](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101140.doc)) Proposal 2-2:
  + The on-demand UE specific calibration gap for the on-the-fly calibration could be considered
* (InterDigital [R1-2100752](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100752.doc)) Proposal 1:
  + - Support distribution of correction information from the LMF to assist the UE to remove timing offsets from measurements
* (InterDigital [R1-2100752](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100752.doc)) Proposal 2:
  + - Support periodic, semi-persistent and on-demand based distribution of timing offset information from the network to the UE.
* (InterDigital [R1-2100752](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100752.doc)) Proposal 3:
  + - For on-demand based distribution of correction information, distribution of timing offset is followed by additional measurement reporting from the UE
* (Samsung [R1-2101210](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101210.doc)) Proposal 1:
  + For UE Rx/Tx timing error mitigation, UE can report the capability for the Rx/Tx timing error estimation and correction. For UEs without the capability of Rx/Tx timing error correction, they can report the antenna panel index associated with PRS reception and SRS transmission to LMF.
* (Qualcomm [R1-2101468](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101468.doc)) Proposal 1:
  + Support UE and gNB reporting enhancements for the purpose of providing information, to the entity performing the positioning calculation, related to which measurements can be assumed to have a same Tx, or Rx, or Rx-Tx timing error.
    - Applicable to both UE-assisted and UE-based methods
    - FFS: Further signaling details, capabilities, procedures.
* (Qualcomm [R1-2101468](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101468.doc)) Proposal 4:
  + Include transmit time difference information for each DL-PRS Resource of a TRP with respect to a reference in the position calculation assistance data
    - FFS: Details on the transmit time difference signaling
* (Ericsson [R1-2101754](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101754.doc))Proposal 1:
  + Specify signaling from the UE to the network of which ‘delay group’ is associated with each SRS-transmission from the UE.
* (Ericsson [R1-2101754](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101754.doc))Proposal 4
  + Include indication of delay group 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 [R1-2101754](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101754.doc))Proposal 5
  + Specify multi delay group RSTD measurements and the corresponding configuration and measurement reporting signalling.

Submitted Proposals (more specific for DL positioning)

* (OPPO [R1-2100128](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100128.doc)) Proposal 1:
  + For DL TDOA positioning, Rel-17 can support the transfer of Tx timing delays of TRPs from NR-RAN node to LMF via NRPPa.
* (OPPO [R1-2100128](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100128.doc)) Proposal 2:
  + For UE-based DL-TDOA method, Rel-17 can support the signaling of the Tx timing delays of corresponding TRPs from LMF to UE via LPP.
* (CATT [R1-2100385](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100385.doc)) Proposal 1:
  + For UE-based DL-TDOA positioning, one of the following methods can be used to help UE eliminate the influence of Tx timing delay and synchronization error of TRPs:
    - Method1: Provide UE the information of Tx timing delays of RF chains of the TRPs for transmitting DL-PRS, or the difference of the Tx timing delays of RF chains between TRPs. The time offset between TRP clocks needs also to be provided if the TRP clocks are not perfectly synchronized.
    - Method2: Provide UE the information of the time synchronization error at the Tx antennas between the TRPs.
* (CATT [R1-2100385](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100385.doc)) Proposal 2:
  + For UE-assisted DL-TDOA positioning, one of the following methods can be used to help LMF eliminate the influence of timing delay and synchronization error of TRPs:
    - Method1: Provide LMF the information of Tx timing delays of RF chains of the TRPs for transmitting DL-PRS, or the difference of the Tx timing delays of RF chains between TRPs. The time offset between TRP clocks needs also to be provided if the TRP clocks are not perfectly synchronized.
    - Method2: Provide LMF the information of the time synchronization error at the Tx antennas between the TRPs.
* (Intel [R1-2100657](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100657.doc)) Proposal 3 (Targeting DL-TDOA):
  + Support gNB TX timing errors measurement report signaling from gNB to LMF (or gNB/LMF to UE), including the estimated timing error difference (Δ*eTX*,*ij*) between the TX timing error for the *i*th (*eTX*,*i*) and *j*th (*eTX*,*j*) nodes (gNBs or TRPs):
    - Δ*eTX*,*ij* = *eTX*,*i* - *eTX*,*j* (i.e. inter gNB Tx-Tx timing error difference)
* (CMCC [R1-2101046](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101046.doc)) Proposal 1:
  + For TDOA-based positioning, a unified framework to estimate Tx/Rx timing errors and NW synchronization error can be defined.
* (MediaTek [R1-2101140](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101140.doc)) Proposal 2-4:
  + For DL-RSTD measurements for DL-TDOA technique, gNB may report the calibrated TX timing delays to the location server, together with the time stamp of making calibration. The location server may further provide the reported TX timing delays of gNBs to UE for UE based mode
* (Ericsson [R1-2101754](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101754.doc))Proposal 6
  + RAN1 should study further under what circumstances the UE should be capable to perform multi delay group RSTD measurements, e.g. if multi delay group 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.

Submitted Proposals (more specific for related UL positioning)

* (OPPO [R1-2100128](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100128.doc)) Proposal 5:
  + For NR UL RTOA based positioning, Rel-17 can support the transfer of Rx timing delays of TRPs from NR-RAN node to LMF via NRPPa.
* (CATT [R1-2100385](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100385.doc)) Proposal 3:
  + For the UL-TDOA positioning, the following method can be used to help LMF eliminate the influence of UE timing delay error:
    - Provide LMF the Tx timing delays of RF chains of the UE for transmitting SRS-Pos, or the difference of the Tx timing delays of RF chains between UE Tx RF chain with index=m and index=n.
* (Intel [R1-2100657](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100657.doc)) Proposal 4 (Targeting UL-TDOA):
  + Support gNB RX timing errors measurement report signaling from gNB to LMF (or gNB/LMF to UE), comprising the estimated timing error difference (Δ*eRX*,*ij*) between the RX timing error for the *i*th (*eRX*,*i*) and *j*th (*eRX*,*j*) nodes (gNBs or TRPs):
    - Δ*eRX*,*ij* = *eRX*,*i* – *eRX*,*j* (i.e. inter gNB Rx-Rx timing error difference)
* (MediaTek [R1-2101140](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101140.doc)) Proposal 2-5:
  + For UL-RTOA measurements for UL-TDOA technique, gNB may autonomously correct the calibrated RX timing delays before reporting the measurements to the location server. The timing delay reporting may not be needed

Submitted Proposals (more specific for Multi-RTT)

* (OPPO [R1-2100128](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100128.doc)) Proposal 7:
  + To reduce the impact of Tx/Rx timing delay on multi-RTT positioning method:
    - The UE may compensate the value of in reported Rx/Tx time difference by implementation
    - The TRP may compensate the value of in reported Rx/Tx time difference by implementation
* (Intel [R1-2100657](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100657.doc)) Proposal 5 (Targeting Multi-RTT):
  + Support gNB TX/RX timing errors measurement report signaling from gNB to LMF (or gNB/LMF to UE), including the total estimated timing error (*ei*) for the *i*th node (gNB or TRP) as a sum of the TX timing error (*eTX*,*i*) and RX timing error (*eRX*,*i*):
    - *ei* = *eTX*,*i* + *eRX*,*i* (i.e. gNB Tx+Rx timing error sum)
* (Intel [R1-2100657](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100657.doc)) Proposal 6:
  + Do not report the total UE TX+RX timing error and keep its estimation and compensation as implementation specific.
* (MediaTek [R1-2101140](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101140.doc)) Proposal 2-6:
  + For UE RX-TX time difference measurements for M-RTT technique, UE may autonomously correct the RX timing delays before reporting the measurements to the location server. Meanwhile, gNB may report the calibrated TX timing delays to the location server, together with the time stamp of making calibration
* (MediaTek [R1-2101140](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101140.doc)) Proposal 2-7:
  + For gNB RX-TX time difference measurements for M-RTT technique, gNB may autonomously correct the calibrated RX timing delays before reporting the measurements to the location server. Meanwhile UE may report the calibrated TX timing delays to the location server, together with the time stamp of making calibration
* (Ericsson [R1-2101754](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101754.doc))Proposal 7
  + Introduce a delay group indication in the UE RX-TX time difference measurement report. Introduce also a coupling between the UE RX-TX time difference measurement and an UL SRS transmission. Let the delay group indication refer both to the TOA measurement and to the SRS transmission.
* (Ericsson [R1-2101754](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101754.doc))Proposal 8
  + Introduce the possibility to configure the UE to perform delay group panel UE RX-TX time difference measurements, i.e. one UE RX-TX time difference measurement for each delay group and TRP.

## Rx/Tx timing error groups

FL Comments

For both UE and gNB, it is expected that a large portion of the RX/TX timing delays will be pre-calibrated for supporting the transmission and reception of the positioning reference signals. The problem we are dealing with should be the remaining RX/TX timing delays, or RX/TX timing errors, after the pre-calibration. If we further consider that the impact of the remaining *RX/TX timing delays* and the UE/gNB baseband clock offsets are not be separable, it might also be more proper to use the term “*RX/TX timing errors”* (as already used by a number of companies), instead of “*RX/TX timing delays”*. In addition, different Rx/Tx antenna panel/RF chains may have the same or different RX/TX timing delays, i.e., RX/TX timing delays are related to individual antenna panel/RF chains. Many companies have proposed to associate RX/TX timing delays with antenna panels /RF chains (e.g., [2][3][5][15][16][17][19]). To avoid directly using antenna panel ID (or RF chain ID) that are tightly associated with physical implementation, it was suggested (e.g., in [19]) to introduce a new term ‘delay group” to represent the transmissions/receptions that have similar timing delays. Thus, it is suggested to introduce the concept of Tx/Rx timing error groups in the following proposal.

Proposal 3-1

The following definitions of Tx/Rx timing error groups are used for the purpose of discussion:

* Tx ‘timing error group’ (Tx TEG): A Tx TEG is associated with the transmission of one or more DL PRS resources, or one or more UL SRS for positioning resources, which have the same Tx timing errors. Different Tx TEGs have different Tx timing errors;
* Rx ‘timing error group’ (Rx TEG): A Rx TEG is associated with one or more DL or UL measurements, which have the same Rx timing errors. Different Rx TEGs have different Rx timing errors.
  + Note: DL measurements included in an Rx TEG may be obtained from DL PRS resources that are in the same DL Tx TEG or different DL Tx TEGs of a TRP. Similarly, UL measurements included in an Rx TEG may be obtained from UL SRS for positioning resources that are in the same UL Tx TEG or different UL Tx TEGs of a UE.

Comments

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| **Company** | **Comments** |
| MTK | 1, Even in a timing error group, the timing error is still time-varying, and the error is the residual after estimation so that the error itself is a random variable  2, if the timing error is a random variable, what is the benefit to define the TEG? The rapporteur can explain more?  3, we think the RX timing delay can be corrected before measurement reporting. So the RX TEG seems not needed |
| vivo | Firstly, we would like to align the understanding of TRP. In the R17 simulation assumption, only one TXRU is supported for TRP, whether different TEG can be seen in a TRP is worth discussing.   | gNB antenna configuration | (M, N, P, Mg, Ng) = (4, 4, 2, 1, 1), dH=dV=0.5λ | (M, N, P, Mg, Ng) = (4, 8, 2, 1, 1), dH=dV=0.5λ – Note 1  One TXRU per polarization per panel is assumed | | --- | --- | --- |   Besides, the benefits and applicable scenario of this definition need to be clarified |
| Huawei/HiSilicon | In our view, the definition here should not be interpreted as being captured as is in the spec. This name is for discussion purposes.  In our understanding, we do not think Tx TEG/Rx TEG should be associated with gNB/TRP side. |
| CATT | Support. The TEG should be associated with the transmission of DL-PRS/SRS-Pos(Tx TEG), or measurements(Rx TEG), which have the same timing errors.The definition of TEG can facilitate the subsequent discussion. |
| FL | For MTK’s comments, the assumption is that there are remaining Tx/Rx errros after the manufacture calibration. The remaining Tx/Rx errros may be random, but biased, and may or many not be further calibrate and/or estimated for improving the positioning performance. One of the purpose of define TEG is to indicate the measurements may be impacted by different timing errors in case different antenna panels with different trains are used for measurements.  For vivo, it is correct that only single TXRU is used as baseline simulation assumption. The issue here is whether in a practical implementation, UE/gNB will always use a single TXRU.  For HW’s comment, yes, the definition of the term is used mainly for the purpose of discussion and potential agreement. |
| InterDigital | Support |
| Qualcomm | Generally support.  To MTK: The UE may be measuring RSTDs on PRS resources that are far away in time. The UE may know that there may be some time drift, so it may choose to say that these RSTD are part of a different RxTEG to suggest to the LMF that maybe these measurements should not be subtrached out. The UE may not know houw much is the time drift. If the UE knows, and can remove it from the report, that’s great; the UE will just say that these 2 RSTDs are in the same RxTEG.  To vivo: Even within a single TXRU, there may be timing differences between the transmitted PRS resources. E.g, different beams resulting to different Transmisison Times of the PRS resources.  To HW: Why it wouldn’t be associated to the gNB? gNBs have timing errors at the Tx and Rx. |
| Nokia/NSB | Is it the correct understanding that Tx and Rx TEG include synchronization offset errors? If yes then we view that as opening the scope of the WID and should inform plenary of this somehow. In addition, we think that phase center offset errors would also fall into these TEGs as we discuss in our contribution and later comments. |
| Ericsson | We are ok in principle. But it is better to separate the UE and TRP TEGs. Plus, the last Note is not needed as it is obvious. We should also emphasize that the timing errors within a certain margin are in the same timing error group.  Revised proposal:   * UE Tx ‘timing error group’ (UE Tx TEG): A UE Tx TEG is associated with the transmission of one or more UL SRS for positioning resources, which have the same Tx timing errors within a certain margin. * TRP Tx ‘timing error group’ (TRP Tx TEG): A TRP Tx TEG is associated with the transmission of one or more DL PRS resources, which have the same 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 same Rx timing errors within a certain margin. Different Rx TEGs have different Rx timing errors. * TRP Rx ‘timing error group’ (TRP Rx TEG): A TRP Rx TEG is associated with one or more UL measurements, which have the same Rx timing errors within a margin. |
| Fraunhofer | Needs clarification.  What does the “same Tx/Rx timing error” refer to? Is it the antenna connector or the antenna phase center. |
| Apple | The definition still needs clarification: 1) is the error the effective error including delay and sync errro or it is only delay error? 2) if it is after calibration then how the error is determined (before we go to the grouping solution), if it is before calibration/compensation/cancellation then in theory UE Rx group and TRP Tx group delays are canceled (respectively for RTOA and RSTD…) I just mean there are details that seems not fully covered by the proposal |
| Huawei/HiSilicon | To QC: In our understanding, for a single TRP, there should be typically a single Tx “TEG” and a single “Rx TEG”, otherwise, they can be separated from TRP level, and perhaps also in addition from frequency layer level within a TRP. For the latter, LMF may maintain the TEG error difference across frequency layers through the reference device, and for UE-based positioning, different RTD values can be provided to the UE on difference positioning frequency layers from the single TRP.  For UE, due to the coverage, multiple chains associated with more than one “TEG” is highly likely even for FR1. |
| China Telecom | We generally support the proposal. But in what condition we can call it the ‘same Tx/Rx timing error’ may need clarification. |
| OPPO | Firstly, we suggest to restrict the terminologies only for discussion now. We cannot predict the exact wording for spec if the corresponding solution is agreed.  Adopt the following definitions of Tx/Rx timing error groups just for discussion:  ….  Secondly, more discussion is needed on the conditions where the time error can be regarded as the same. It is likely RAN4 should be involved |
| vivo2 | To QC: In SI, we have proposed clarifying the reason and scope of Rx/Tx Timing error. Unfortunately, there is no agreement or conclusion for it. But we think it was caused by the group delay between the Baseband unit and Radio Frequency unit and are generated per panel independently as the following agreement.   |  | | --- | | Agreement:  Optional: The UE/gNB RX and TX timing error, in FR1/FR2, can be modeled as a truncated Gaussian distribution with zero mean and standard deviation of T1 ns, with truncation of the distribution to the [-T2, T2] range, and with T2=2\*T1:   * T1: [X] ns for gNB and [Y] ns for UE * FFS: X, Y * Note: RX and TX timing errors are generated per panel independently * FFS: how the Rx and Tx timing errors are applied |   If “even within a single TXRU, there may be timing differences between the transmitted PRS resources”, we think it out of R17 scope. |
| ZTE | 1. Do not support the first bullet. We think that the granularity of dividing TRPs to different TEGs are too small. TRPs are assumed to calibrate the timing delays between different TEGs inside itself by implementation while UE may not have this capability. 2. Support the second bullet. A UE may have different RF chains and doesn’t have the capability to calibrate between different RF chains. |
| LG | We are supportive of the modified proposal for the purpose of the discussion, but we have a similar clarification question on whether this timing error includes sync error or not. |
| MTK | Our understanding is,  1, for different RF chain for transmission or receiving, we can’t assume that the delay is the same  2, for the same RF chain, the delay is still time varying due to temperature-dependent nature at RF part. This means we can’t assume the delay is always the same under same RF chain for transmission/receiving  3, UE may compensate its own RX timing delays, no matter using which panel for receiving. The residual error after compensation is a random variable which can’t be derived. Otherwise and similarly, we can derive white noise value and cancel it, then the channel coding is not needed anymore  Some feedback for QC’s explanation (thanks Alex).  For one RSTD measurement, it is to take the differential of two time of arrival measurements. We see the following conditions. For a UE,  1, If the two TOA measurements are conducted at the same time instance and by the same RF chain and same frequency layer, then RX side timing delay would be cancelled for this RSTD measurement  2, If the two TOA measurements are conducted at different time and by the same RF chain and same frequency layer, then RX side timing delay may not be cancelled perfectly for this RSTD measurement. We need to understand whether this is useful case, because DL-PRS is comb structure, which allows multiple TRPs to transmit at the same time. So UE can form the RSTD measurement based on the TRPs transmitting at the same time (same slot, different comb index). If UE reports this RSTD value to location server and notify that, the two TOA measurements are performed at different time instance, what the location server can do? Drop it? If location server would drop it, why UE sends such reporting? It waste uplink resource  3, If the two TOA measurements are conducted at the same time and by different RF chain, for example, different panels and same frequency layer, then RX side timing delay may not be cancelled perfectly for this RSTD measurement. For this case, UE may support simultaneous reception from two panels (with different QCL type-D), and this should be UE capability. Also, if UE reports this RSTD to location server, and also reports that the RSTD is derived by different TEG, then what the location server can do? The root cause should be, UE should avoid using different panels to receive for getting RSTD under higher accuracy requirement  4, If the two TOA measurments are conducted at the same time and by different RF chain, for example, using same panel and different frequency layer, the RX side timing delay may not be cancelled perfectly for this RSTD measurement. This is because the RF side timing delay could also be frequency dependent (nature of RLC filters in RF circuit). For this case, we wonder why higher accuracy positioning (especially for IIOT scenario) considers inter-freq measurement for positioning?  5, If the two TOA measurement are conducted at different time and by different RF chain, then RX side timing delay may not be cancelled perfectly for this RSTD measurement. And this case should be avoided for higher accuracy purpose  6, if one RSTD measurement using two TOA measurements at the same time, say T1, and by the same RF chain, and another RSTD measurement using other two TOA measurements at the same time, say T2, and by the same RF chain. T1 != T2, then both the two RSTD measurements are not impacted by RX side timing delay  So, we really doubt what the location server can do when UE reports a RSTD value in which the two TOA measurements are from 2 RX TEG  Therefore, we don't think RX TEG is so needed. |
| Huawei/HiSilicon | To MTK:  For case 3, our understanding is that it may be possible that different Rx/Tx chains at the UE may not have the simultaneous visibility/quality toward the same TRP. Identify the UE Rx/Tx TEG info may be helpful. This is applicable to both FR1 and FR2. |
| MTK | To HW:  UE’s panels may have different “visibility” due to cell phone time-varying orientation. Our point of view is, when forming a RSTD measurement, the two TOA measurements may need to be from the same panel for receiving.  We don't see the benefit that we form a RSTD measurement by the two TOA measurements from different panels for receiving. And then UE tells the location server that I do so. What location server can do after getting this message?  For a same pair of TRPs for transmission, UE may use different panels for measurement, each panel to derive its own RSTD measurement. UE can choose to report the RSTD measurement based on the receiving from the panel of good quality. This is UE implementation. We also want to understamd how it could be helpful if UE reports such panel information (or RX TEG) to location server? |
| FL | It is important for us to have the same undersytanding on whether there is a need to introduce the concept of “timing error group”, and whether to we need to have all of the four TEGs, namely TRP Tx TEG, TRP Rx TEG, UE Tx TEG, and UE Rx TEG. My suggestion is to use some online time to discuss it, so we will all in the same undersytanding. |

Proposal 3-1 (Revision 1)

The following definitions of Tx/Rx timing error groups are used for the purpose of discussion:

* UE Tx ‘timing error group’ (UE Tx TEG): A UE Tx TEG is associated with the transmission of one or more UL SRS for positioning resources, which have the same Tx timing errors within a certain margin.
* TRP Tx ‘timing error group’ (TRP Tx TEG): A TRP Tx TEG is associated with the transmission of one or more DL PRS resources, which have the same 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 same Rx timing errors within a certain margin. Different Rx TEGs have different Rx timing errors.
* TRP Rx ‘timing error group’ (TRP Rx TEG): A TRP Rx TEG is associated with one or more UL measurements, which have the same Rx timing errors within a margin.

Comments

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| **Company** | **Comments** |
| CATT | Support Proposal 3-1. In any case, we can discuss whether the concept of TEG should be introduced. For the timing delay error information in transmitting side (including UE transmitting SRS-Pos in UL-TDOA, or TRP transmitting DL-PRS in DL-TDOA, the Tx TEG look like necessary information, for LMF or UE to mitigate the timing delay error. Maybe we can firstly converge on this point, i.e., the necessity of UE Tx TEG and TRP Tx TEG. For the timing delay error information in transmitting side, RX TEG may be optional considering that the receiver maybe compensate the timing delay error when reporting the measurement results. So, our suggestion is to first discuss whether TX TEG needs to be introduced. |
| Nokia/NSB | First, thanks to the FL for the effort to mangage the difficult discussion. Overall we are okay to introduce such definition but as commented online we feel that this proposal is continuing to kick the can down the road by not defining what “Tx timing errors” means. It is clear from contributions and discussion that different companies have different understand of what is included in these timing errors. Perhaps as a way forward we could first agree to something which lists the options like the following (just draft version):  Proposal:  Timing Errors include:   * Option 1: Group delays * Option 2: Synchronization offset delays * Option 3: Phase Center offset delays * Option 4: Combination of 1+2. * Option 5: Combination of 1+3. * Option 6: Combination of 1+2+3.   From our side we support option 5 as we see this issue being most critical for multi-RTT where synchronization offset is already not a factor but we are open to other options as well. Companies could then study these different options leading up to RAN1#104-b. |
| FL | For NOK’s comment, the issue here is that depending on the understanding of the synchronization offset.  If the time synchronization error is the timing error at the TRP Tx antenna, then includes Option 1, gNB clock offset and Option 3. If the time synchronization error refers only to gNB clock error, then Option 2 may not be separable from Option 1 and Option 3. Please also see my comment in the following table. |
| ZTE | As we commented in GTW session, the definition of timing errors should be clarified and TEGs at UE side should be considered first.   1. the TRP is assumed to have the capability to calibrate timing errors between different RF chains, which is kind of an implementation work. 2. At UE side, some UEs may have different RF chains and low capability, different RF chains cannot calibrated with each other. In this situation, UE may request TRPs to send PRSs towards RF chain 1 or RF chain 2, UE can transmit through RF chain 1 or RF chain 2, and the RF chain information(TEG information) should be defined so that LMF can combine the schemes with the same UE TEG, e.g. DL-TDOA+UL-TDOA. |
| MTK | Okay, let me use the following figure to discuss, and also leverage Nokia’s proposal in above    1, in SI, we seem to consider the group delay between antenna to ADC, and the delay between DAC to antenna, as the TX timing delay and RX timing delay respectively. The group delay is mainly induced by the RLC filters of RF circuit  2, In the beginning we think that if we use “timing error” here, it should be a residual (and differential) value between an unknown group delay value and the estimated value. If we don't estimate it, then the timing error would represent the whole unknown group delay value. Now it seems that it is open to consider more impairments. We illustrate in below  3, In the figure, as we look at the parameter “mu”, it is the time offset between TRP TX slot timing and UE RX slot timing (and we assume TRP TX slot timing and TRP RX slot timing are aligned). Normally “mu” would be related to TOF between UE and its serving cell. “mu” could be changed due to sampling clock offset so that UE have the symbol length not exactly equal to that of gNB. For example, gNB transmits with the elementary period Ts (32.55ns), but UE’s elementary period is (1+ 1e-6)\*Ts. gNB may also have the sampling clock offset. From UE perspective, “mu” can be adjusted dynamically at least based on using TRS to observe channel impulse response. We can also say that **“mu” is related to sampling clock offset difference between a TRP and a UE**. So it looks like **“mu” belongs to option 2.** It is one digital clock, even though there are multiple panels in UE side.  4, in the figure, as we look at the parameter “delta”, it is the time offset between 2 TRPs (synchronization error). “delta” could be time varying because each TRP has its own sampling clock offset. Therefore, **“delta” is related to sampling clock offset difference between 2 TRPs**. So it looks like **“delta” also belongs to option 2. “delta”** can be cancelled by combining the DL-RSTD and UL-RSTD measurements ( differential of 2 UL-RTOAs), or consider the combination of UE RX-TX time difference measurement and gNB RX-TX time difference measurement  5, phase center of antenna seems to have been considered under GNSS for higher accuracy. Frankly speaking, we are not quite familiar with it. It deserves more study so we are not objecting it  6, Our current position for timing error definition is to slightly modify option 1 and keep option 5 FFS,   * Option 1: Group delays   + Note: it is a differential value between an unknown group delay value and its estimated value. If it is not estimated, then the timing error represents the whole unknown group delay value * FFS on Option 5: Combination of 1+3 (Option 3: Phase Center offset delays).. |
| OPPO | Without the specific value of the margin, we cannot know whether it is feasible for TRP/UE to make any decision based on these definitions:  1. If the margin is a large value, it is useless  2. If the margin is a small value (e.g., ns level) , from RAN1 perspective, it is not clear whether TRP/UE can measure the timing difference with sufficient accuracy. We should consult RAN4 on this issue.  If RAN1 decides to introduce the concept of “timing error group”, it should be used for both UE and TRP.  p.s., I withdraw my second comment raised in GTW session. |
| LG | We have a similar comment. We are OK to define the terminology for the purpose of the discussions, but a certain margin is unclear to us. We would like to avoid strong debate to define the value of a margin. |
| FL | To MTK: For bullet 4 in the comments, my understanding of the parameter “delta” in the Figure is the time offset between 2 TRPs clocks, but not TRP synchronization error. The TRP synchronization error is (delta + TRP2 Tx timing delays – TRP1 Tx timing delays), since the reference point of TRP timing synchronization is defined at TRP Tx antenna but not at internal clocks.  For OPPO’s comments on the margin, I share the similar view as LG that the details of margin can be further discussed once we have the same views on the definition of Tx/Rx timing errors and the need to introduce the concept. |
| Ericsson | In our understanding, ‘margin’ defines how close the timing error difference need to be in order for two transmissions or two measurements to belong to the same TEG. For example, if the timing error difference associated with two transmissions are within the margin, then the two transmissions belong to the same Tx timing error group (Tx TEG). As to defining the values of these margins, it probably needs to be discussed in RAN4.  As per the definition of timing error, our understanding is Option 1 in MediaTek’s response. Note that synchronization error mitigation was discussed at length during the SI phase, and it is out of scope from the Rel-17 enhanced positioning WI. So, timing error definition should exclude synchronization errors.  We suggest to remove ‘Different Rx TEGs have different Rx timing errors’ from the third bullet in the proposal as the other three bullets don’t have such description. See suggested change below:  The following definitions of Tx/Rx timing error groups are used for the purpose of discussion:   * UE Tx ‘timing error group’ (UE Tx TEG): A UE Tx TEG is associated with the transmission of one or more UL SRS for positioning resources, which have the same Tx timing errors within a certain margin. * TRP Tx ‘timing error group’ (TRP Tx TEG): A TRP Tx TEG is associated with the transmission of one or more DL PRS resources, which have the same 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 same Rx timing errors within a certain margin. ~~Different Rx TEGs have different Rx timing errors.~~ * TRP Rx ‘timing error group’ (TRP Rx TEG): A TRP Rx TEG is associated with one or more UL measurements, which have the same Rx timing errors within a margin. |
| FL | To MTK: For bullet 4 in the comments, my understanding of the parameter “delta” in the Figure is the time offset between 2 TRPs clocks, but not TRP synchronization error. The TRP synchronization error is (delta + TRP2 Tx timing delays – TRP1 Tx timing delays), since the reference point of TRP timing synchronization is defined at TRP Tx antenna but not at internal clocks.  For OPPO’s comments on the margin, I share the similar view as LG that the details of margin can be further discussed once we have the same views on the definition of Tx/Rx timing errors and the need to introduce the concept. |
| OPPO | Reply to FL and LG’s comment: we would like to make some further clarification. What we have concern on is whether UE is feasible to make any decision based on the current concept. If UE wants to claim some receptions/transmissions within the same TEG, UE should ensure that the timing difference should be within the margin. In order to accomplish the procedure, some measurement should be done. Is it feasible for UE/TRP to do such kind of measurement? We don’t know so far. If it is infeasible, then UE/TRP will claim each reception/transmission is associated with a different TEG. In this case, the concept of TEG is useless. |
| China Telecom | In our understanding, the TEG is a concept that associated with the physical configuration and realization of the UE/TRP on Tx/Rx. At least just for its definition, it should be symmetrical. The issues related to TEG including the definition of Tx/Rx Timing Erros, the value of margin, whether the TEP at TRP or RX side is useful do need further discussion. But we may just endorse this proposal for the definition for convenience. It doesn’t mean that all the bullets should be included in CR, but it can be the fundamental of the next proposals. After we decide how should the TEG used for positioning enhancement, then down select which bullets can be included in CR. |
| OPPO | During the discussion, some companies mentioned that it is benefical for LMF to know the TEG. Here we take a UE with 2 panel with example. For UL transmission, UE transits SRS for TRP1-5 with panel 2 and SRS for TRP A-C with panel 1.  **If the two panels are with different Tx timing error**, the the measurement result at Group 1 (TRP1-5) and at Group 2 (TRP A-C) cannot be differentiated. Then, LMF can only a set X of UL TDOA results based on Group 1 and another set Y of UL TDoA results based on Group2. As we discussed in the study stage, only when several TRPs are around the UE, the positioning method can achieve high accuracy for Rel-17 targets.   * Since UE is at the right side of Group 1, the location estimation based on set X will suffer a relatively large error. * Estimation based on set Y (Group 2) is similar as above * Joint use of set X and set Y cannot achieve higher accuracy as well   Thus, in this case, even if LMF knows the information, it is difficult for the accuracy of the positioning to meet the requirement of Rel-17 ePos.  The similar analysis is also applicable for Rx timing error. |
| FL | For OPPO’s comments,   1. As comented from China Telecom and other companies, the definitions used used for the purpose of discussion. I will add a note “The use of the above definitions of UE/TRP Tx/Rx TEGs does not necessarily mean they will be introduced in Rel-17” to see if it can address OPPO’s concern; 2. Foro the example shown by OPPO above, if LMF does not know the there are two TEGs. Then, the LMF may mix the measurements from TRP 1-5 and TRP A, B, C, to get 7 measurements which are impacted by Rx/Tx timing errors. On the other hand, grouping TRP 1-5 and TRP A, B, C separately have the potential to have 6 measurements which are not impacted by Rx/Tx timing errors. |

Proposal 3-1a (Revision 2, Revised)

The following definitions of Tx/Rx timing error groups are used **for the purpose of discussion**:

* UE Tx ‘timing error group’ (UE Tx TEG): A UE Tx TEG is associated with the transmission of one or more UL SRS resources for positioning, which have the same Tx timing errors within a certain margin.
* TRP Tx ‘timing error group’ (TRP Tx TEG): A TRP Tx TEG is associated with the transmission of one or more DL PRS resources, which have the same 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 same 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 same Rx timing errors within a margin.

Note: The use of the above definitions of UE/TRP Tx/Rx TEGs does not necessarily mean they will be introduced in Rel-17.

Comments

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| **Company** | **Comments** |
| Nokia/NSB | We can be okay with this proposal in order to make progress but suggest to also agree on some options for the definition of timing errors (perhaps for downselection at RAN1#104-b). If we don’t have clarity on what timing errors means then this definition will just cause problems later on. |
| CATT | Support. |
| Intel | We propose to start the work from single panel case UE and then generalize framework on multi-panel case. |
| Huawei/HiSilicon | We prefer to have the following change on the first bullet.   * UE Tx ‘timing error group’ (UE Tx TEG): A UE Tx TEG is associated with the transmission of one or more UL SRS resources, which have the same Tx timing errors within a certain margin.   We also wonder why only the third bullet has “Different Rx TEGs have different Rx timing errors.” |
| FL | For NOK’s comments:   * Proposal 3-1b is added for the definition of the Rx/Tx timing errors;   For Intel’s comments:   * The definition of the TEGs are used for discussion. We would need to have the same understanding of the definition for the discussion on whether to introduce TEGs in Rel-17.   For HW’s comments:   * It sould be “SRS resource for positioning” instead of “SRS for positioning resources”. * “Different Rx TEGs have different Rx timing errors” can be removed for now. I iwould assume we will need to discuss how to separate TEGs once we agree to introduce TEGs. |

Proposal 3-1a (Revision 2, Revised)

The following definitions of Tx/Rx timing error groups are used **for the purpose of discussion**:

* UE Tx ‘timing error group’ (UE Tx TEG): A UE Tx TEG is associated with the transmission of one or more UL SRS resources for positioning purpose, which have the same Tx timing errors within a certain margin.
* TRP Tx ‘timing error group’ (TRP Tx TEG): A TRP Tx TEG is associated with the transmission of one or more DL PRS resources, which have the same 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 same 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 same Rx timing errors within a margin.

Note: The use of the above definitions of UE/TRP Tx/Rx TEGs does not necessarily mean they will be introduced in Rel-17.

Discussion of the definition of Tx/Rx Timing Errors

Based on the offline/online comments, some companies requested the clarification of the Tx/Rx timing errors as well as the relationship with gNB time synchronization before further discussion of TEGs:

1. The definition of Tx timing error and Rx timing error;
2. The relationship between gNB Tx timing error and gNB time synchronization;
3. The impact of Tx timing error and Rx timing error on the timing related measurements;

Interested companies are invited to present their views in the following table.

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| **Company** | **Comments** |
| FL | 1. The definition of Tx timing error and Rx timing error;   First, the reference point of timing related measurements are defined at Tx/Rx antenna (or antenna connector).  The true TOA is the time when a signal arrives at the Rx antenna.  The measured TOA is the time that the estimated (observed) TOA of the signal at the Rx antenna in BB processing  Rx timing error = (the estimated TOA) – (the true TOA)  Rx timing error is impacted by the Rx RF chain delays if not fully compensated and receiver internal clock offset.  Different Rx RF chains/panels may have different RF delays.  The real TOD is the time when a signal departures from the Tx antenna.  The calculated TOD is the time of the calculated TOD of the signal at the Tx antenna in BB processing  Tx timing error = (the real TOD) - (the calculated TOD)  Tx timing error is impacted by the Tx RF chain delays if not fully compensated and also transmitter internal clock offset.  Different Tx RF chains/panels may have different RF delays.   1. The relationship between gNB Tx/Rx timing error and gNB timing synchronization error   Network Tx time synchronization requirements are defined at the TRP Tx antennas. If a network is precisely time synchronized, then the DL PRS signals leaves TRP Tx antenna at the same time. Tx timing errors can be seen as zero. Thus, the estimation and calibration of the TRP timing errors equals to the estimation and calibration of the TRP synchronization errors.  For TRP Rx timing, there is so far, to my knowledge, no time synchronization requirements, although to support UL TDOA, the network needs to implement TRP Rx time synchronization.   1. The impact of Tx timing error and Rx timing error on the timing related measurements   DL RSTD measurement accuracy is impacted by difference of TRP Tx timing errors and UE Rx timing error;  UL RTOA measurement accuracy is impacted by UE Tx timing error and TRP Rx timing error;  UE Rx-Tx time difference measurement accuracy is impacted by UE Tx timing error and UE Rx timing error;  gNB Rx-Tx time difference measurement accuracy is impacted by TRP Tx timing error and TRP Rx timing error; |
| MTK | Our comments in above may also apply here |
| vivo | Maybe “doesn’t” is missing in the following part  For TRP Rx timing, there is so far, to my knowledge, no time synchronization requirements, although to support UL TDOA, the network doesn’t need to implement TRP Rx time synchronization. |
| Huawei/HiSilicon | We suggest to have the following clarification.  1. Clarification #1: TEG is the concept to differentiate something INTERNAL for a node (TRP/UE), which means different nodes should naturally be regarded as different TEGs, e.g. different TRP already belongs to different TEGs, and a TRP and a UE belongs different TEGs.  2. Clarification #2: The necessity to enable the TEG concept for a node, replies on that the node has at least two “TEGs” for a single link direction.  3. Clarification #3: Different TEGs can be collocated.  4. Clarification #4: TEGs within a node can be implicit, e.g. different positioning frequency layers on different bands may belong to different TEGs for both TRP and UE.  5. Clarification #5: Inter-TEG error mitigation should include intra-node TEG error mitigation (e.g. different panel identification), and inter-node TEG error mitigation (Rx/Tx timing error calibration between TRPs).  Regarding clarification from Nokia, our understanding is that the purpose of introducing TEG is targeting group delay. Whether the method to mitigate the inter-TEG error can also be applied to phase offset and baseband clock error can be up to implementation.  For phase offset, we would like to understand whether the phase centre changes over the beam coefficient or a target direction. In our understanding, this may require beam-specific or UE/TRP specific ARP change. We understand the motivation here is for UE even using the same Tx/Rx with different beamformer or toward different TRP, the TDOA method cannot entirely cancel the offset.  Regarding the interpretation of the FL on the questions, it is aligned with our understand.  Regarding the comment that Rx TEG is not needed to define, our understanding is that it is only valid that if the same RS is received by the concerned Rx’s at the same time. However, this may not be the case due to blockage issue, especially at UE side. Even if the signal can be received by multiple Rx’s at the same time, we are not clear whether Rx group delay is comparable with the geographical distance between the Rx’s. |
| OPPO | 1) **Tx timing error:** From the perspective of positioning accuracy, it is more useful to consider the Tx timing dfferences between the transmissions of the different RS resource. Thus, it should include group delays, synchronization offset delays, phase Center offset delays and some other potential factors  **Rx timing error:** In addition to the factors pointed by FL, we would like to add one factor for UE: UE may adjust the Rx timing based on the SS/TRS of the serving cell.  2) It is difficult, if not impossible, to differentiate the impact of different factors (e.g., group delay, un-perfect synchronization) on the “timing delay” |
| FL | To vivo’s comments, for UL TDOA, the reference point of Rx time of RTOA is Rx antenna. Thus, my understanding is that the network needs support the Rx time synchronized for all TRPs.  For HW’s comments, “Clarification #1 ~ 5”, I basically share the same understanding.  For OPPO’s 1st comment: I share the same view that Tx timing error is associated with RS resources, e.g., one TRP Tx TEG may be associated with one or more DL PRS resources. For Rx timing error, it is unclear to me how adjustment of the Rx timing impact the Rx timing error. I assume the value of the time adjustment is known to the UE, and thus, should be compensated in the reported measurement. |
| CATT | We share the same views with FL. In Rel-16, all the time-based measurement, including RSTD, RTOA or Rx-Tx time difference, measured by UE or TRP between their antenna as defined in TS 38.215. Synchronization error may be integrated with the Tx timing delays together, and they can't be divided into two separate parts. |
| Huawei/HiSilicon | I am a bit confused by “UE may adjust the Rx timing based on the SS/TRS of the serving cell” raised by OPPO. Why would serving cell DL sync affect positioning? To my understanding, positioning can work without serving cell at all.  For TDOA based positioning, as long as the UE Rx timing error is common for the RSTD TRPs (likewise, the UE Tx timing error for the UL RTOA TRPs), they can be cancelled. This problem will raise if UE has two Rx chain (Tx chains) each associated with its independent error source, but we do not see why it is related to the DL timing of the serving cell.  There should be some clock drift at UE side, resulting in PRS Rx timing slightly deviated from one slot to another slot, but even 0.2 ppm clock will only deviate maximum 200ps for every 1ms, which should have very small impact on the accuracy if PRS reception is within two slots.  From our side, we see RSTD grouping based on UE Rx TEG and UL RTOA grouping based on UE Tx TEG a good feature. As for TRP side TEG, for indoor use case, we are OK to keep it on the table, but it needs further study on the use cases.  To CATT, in my understanding, synchronization error can be more easily mitigated than group delay error, e.g. using multi-RTT or DL-TDOA+UL-TDOA (differential multi-RTT). However, if the group delay error can somehow be mitigated using a method, synchronization error can also likely be mitigated. |
| Fraunhofer | Assuming an antenna array the effective antenna position (“phase center”) may be different for each beam, especially if several (sub-)panels are used. The Tx and Rx timing error shall be dependent on to this effective antenna position. If the true timing delay is the time when the signal is transmitted from or arrives at the effective position (phase center) of a beam, a TEG is therefore applicable to beams having the same phase center.  We do not see the issue from the phase offset conflicting: the information or assumptions an LMF (or UE-based) can make is what matters. If the TEG is originating from the same beam then “the certain margin” as defined in the P3-1 is low. If the Tx/Rx or TEG is originating from the group delay then “the certain margin” can be cm-range and that can be valuable information at the LMF.  In other words, we can refine/conclude on the timing delay definition as per Nokia’s Option5 or agree that error margin may depend on the phase center offsets which makes P3-1 more clear. |
| Qualcomm | Understanding of FL and HW is aligned to what we have in mind. We do NOT try to include network synch within this scope. Network synch is about the Transmit Time difference between 2 TRPs. Timing errors is about the INTERNAL uncenrtainty between the actual Tx (Rx) time from the antenna connector and the one the device thinks indeed it was. This picture shows it clearly we think. It’s the group delays between the baseband and the actual antenna and how well a device knows these delays. |
| Nokia/NSB | We basically share the same view as Fraunhofer above and agree that if clarified the TEG concept can apply to the phase center offset issue (e.g., option 5). It is clearer now that we are discussing errors that are internal to one UE/TRP, as QC points out, and we agree that network sync is not in scope. Therefore, the synch error seems a separate topic but that should be clarified somehow in an agreement or definition. |
| Ericsson | As commented by Qualcomm above, network synchronization error is not in scope of the WID. As for the definition of timing error, we prefer Option1 in the previous question which is copied below:   * Option 1: Group delays   + Note: it is a differential value between an unknown group delay value and its estimated value. If it is not estimated, then the timing error represents the whole unknown group delay value |
| Huawei/HiSilcon | We have always be wishing to comment on the figure that QC used.  To our understanding, or other parameter serving the same purpose should not be the BB-Ant group delay, but rather the residual error after the best effort compensation of group delay by gNB and UE. So technically the reported gNB/UE Rx – Tx time should be the one estimated on the antenna of gNB/UE, and can be negative. |
| OPPO | To reply FL and Huawei’s comment: For one measurement of DL TDOA, the UE can ensure to compensate the known Rx timing error if it adjusts the timing based on the serving cell’s SSB. However, in some case (for example, some use case of Proposal 2-1), UE don’t know which measurements will be used by LMF for joint processing. In these cases, UE don’t know it should compensate the Rx timing error for two different reporting of measurements. |
| vivo2 | Thanks for the good discussion, we would like to confirm our understanding is right that if the timing of 2 TRP is different because of timing group delay, should it be seen as a sync error other than Tx/Rx Timing error in TDOA method? |
| MTK | To FL:  1, we think the gNB synchronization error is the slot timing difference between TRPs in **baseband point of view**. It is mainly influenced by the sampling clock offset between TRPs. Therefore, we consider it to be defined in baseband, not in antenna. And therefore, synchronization error should be **independent** of what we want to discuss the timing delays/errors. Synchronization error is not in the scope  Further views on TEG, we have comment on Huawei’s clarification #2, which says that “Clarification #2: The necessity to enable the TEG concept for a node, replies on that the node has at least two “TEGs” for a single link direction”  In our views,  1, for UE transmission, and UE has panel number >= 2, it is natural to think that the TX timing delays for 2 panels would be different. For UL-RTOA measurements, the location server may take difference on 2 UL-RTOA measurements to form a UL-RSTD value. If the 2 UL-RTOA measurements (each from a TRP) are measured from the UE with **same panel transmission** and **same SRS time occasion,** then the TX timing delay due to UE can be cancelled. The SRS transmission from same panel and different time occasion can’t guarantee that TX timing delay would be the same. We think **TX TEG at UE could have the need to be defined**  2, for UE receiving, and UE has panel number >= 2, it is natural to think that the RX timing delays for 2 panels would be different. For DL-RSTD measurements, unless that UE simultaneous enable 2 panels for receiving, each panel for one TOA (time of arrival) measurement, otherwise, the RX timing delay can be cancelled for DL-RSTD measurement under same panel and same PRS occasion for receiving   * If UE enables a single panel to receive at each PRS occasion, then the RX timing delay can be cancelled for DL-RSTD measurement * If UE simultaneously enable 2 panels to receive at each PRS occasion, simple to say,   Receive from Panel A for TRP1 🡪 delay = ΔtTX\_tp1  + tof1 +ΔtRX\_ue\_pA (a)  Receive from Panel A for TRP2 🡪 delay = ΔtTX\_tp2  + tof2 +ΔtRX\_ue\_pA (b)  Receive from Panel B for TRP1 🡪 delay = ΔtTX\_tp1  + tof1’ +ΔtRX\_ue\_pB (assume panel A and panel B only a fiew centi-meter away from each other, so that tof1 is very close to tof1’ ) (c )  Receive from Panel B for TRP2 🡪 delay = ΔtTX\_tp2  + tof2’ +ΔtRX\_ue\_pB  (d)  Then UE can observe the RX time delay difference between 2 panels **at the same PRS occasion** by (a) and (c), and also by (b) ans (d). If UE chooses to reports a DL-RSTD based on TOA measurement from 2 different panels, for example from (a) and (d), or (b) and (c), then the RX time delay difference between 2 panels can also be cancelled **before reporting DL-RSTD**.  From our side, we don't prefer simultaneously to enable 2 panels for receiving, because seriously, tof1 != tof1’ and tof2 != tof2’ in above  Therefore, we think RX TEG at UE doesn't need to be defined  3, for TRP receiving and transmission, it seems that some infra vendors don’t consider multiple-panels, we respect this opinions and then TX TEG and RX TEG at gNB may not need to be defined |
| ZTE | Regarding FL’s second bullet of the comment, we agree with MTK’s comments that the gNB timing synchronization is between multiple TRPs, and if multiple TRPs are precisely time synchronized, it means DL PRSs of multiple TRPs leave the corresponding TRP **baseband at the same time**. However, different TRPs may have different group delay, so PRSs of multiple TRPs leave the corresponding TRP **antenna at different time.** Thats why even if when TRPs are precisely time synchronized, (Tx group delay of TRP1)-(Tx group delay of TRP2) is still needed to be calibrated or estimated in DL-TDOA method. |
| LG | Thanks for the clarificatios. Then, we understand that the timing error only considers the group delay resulted from inherent delay between BB and antenna and time synchronization error is not included, where the syncrhonization error would be an independent issue. |
| Intel | 1. RAN1 needs to consult with RAN4 2. Our understanding it is remaining/residual error which is not known/compensated at UE/TRP side unless special calibration procedures are used 3. Introduce error into measurement and positioning equations |
| Nokia/NSB | Thanks for the good technical discussion. We agree with Huawei that the error should be after best effort to mitigate it. Seems that most companies also agree that synchronization offsets between TRPs is not included here. We suggest the following updated proposal:  Timing Errors include:   * Option 1: Group delays * Option 2: Phase Center offset delays * Option 3: Combination of 1+2.   We support option 3 but are okay to agree as options to be discussed at RAN1#104-b as companies will have time to dig into the issues more. |
| FL | Based on the comments, I added the following Proposal 3-1b for the definitions of Tx/Rx timing errors |

Proposal 3-1b (Revised)

The following definitions of Tx/Rx timing errors are used for the purpose of discussion:

* **Tx timing error**: From signal transmission perspective, there will be a time delay from 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 normally needs to implement the internal calibration/compensation of the Tx time delay when it transmits the DL PRS/UL SRS signals. The compensation may also possibly consider the offset of the Tx antenna phase center to the antenna center. However, the calibration may not be perfect. The remaing, uncalibrated Tx time delay is called as *Tx timing error*.
* **Rx timing error**: From signal reception perspective, there will be a time delays from time when the RF signal arrives the Rx antenna to the time when the signal is digitized and time-stamped at baseband. For supporting positioning, the UE/TRP normally needs to implement internal calibration/compensation of the Rx time delay before it reports the measurements that are obtained from the DL PRS/UL SRS signals. The compensation may also possibly consider the offset of the Rx antenna phase center to the antenna center. However, the calibration may not be perfect. The remaing uncalibrated Rx time delay is called as Rx timing error.

Comments

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| **Company** | **Comments** |
| Huawei/HiSilicon | One general comment is what “this document” is. I tend to think that we are trying to make an agreement for this proposal? |
| FL | For HW’s comments, yes, the intention is to make an agreement/conclusion for this proposal. “in this document” should be removed. |

Proposal 3-1 (Revision 3)

The following definitions are used for the purpose of discussion:

* **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. 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. 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 same 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 same 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 same 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 same 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 same ‘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 same ‘Rx timing errors+Tx timing errors’ within a certain margin.

Note: The use of the above definitions of UE/TRP Tx/Rx/RxTx TEGs does not necessarily mean they will be introduced in Rel-17.

Comments

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| **Company** | **Comments** |
| Qualcomm | Tu |
| MTK | According to the definition by FL:   * “Estimation of Rx/Tx timing delays”: It means the estimation of the values of the UE/gNB Rx/Tx timing delays for supporting the mitigation of Rx/Tx timing delays; * “**Calibration/Compensation of Rx/Tx timing delays”: It means the use of the estimated/known Rx/Tx timing delay values to remove the impact of the UE/gNB Rx/Tx timing delays**; * “Cancellation of Rx/Tx timing delays”: It means the cancellation of the impact of the UE/gNB Rx/Tx timing delays on the measurements or position solutions without the necessity of estimating the values of Rx/Tx timing delays. * “Mitigation of Rx/Tx timing delays”: It is a general term, which means the mitigation of the impact of Rx/Tx timing delays on the timing measurements and position solution with any of potential approaches.   In earlier round, we and E/// express that the timing error may also contain the case without any calibration/compensation. The timing error could be estimated, and the estimation is always not perfect so that there would be residul left after the compensation. Therefore the timing error means the difference between the actual unknown value and the estimated value. If the estimation is not performed, the timing error will represent the whole unknown value.  So we suggest the following wording change of the definition,   * **Tx timing error**: From signal transmission perspective, there will be a time delay from 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 normally needs to implement the internal calibration/compensation of the Tx time delay when it transmits the DL PRS/UL SRS signals. The compensation may also possibly consider the offset of the Tx antenna phase center to the antenna center. However, the calibration may not be perfect. The remainin Tx time delay after calibration, or that without any calibration, is defined as Tx timing error. * **Rx timing error**: From signal reception perspective, there will be a time delays from time when the RF signal arrives the Rx antenna to the time when the signal is digitized and time-stamped at baseband. For supporting positioning, the UE/TRP normally needs to implement internal calibration/compensation of the Rx time delay before it reports the measurements that are obtained from the DL PRS/UL SRS signals. The compensation may also possibly consider the offset of the Rx antenna phase center to the antenna center. However, the calibration may not be perfect. The remaining Rx time delay after calibration, or that without any calibration, is defined as Rx timing error.   The wording change for the Note is also needed after QC suggests the RxTx stuff  Note: The use of the above definitions of UE/TRP Tx/Rx/RxTx TEGs does not necessarily mean they will be introduced in Rel-17. |
| vivo | In general, we agree with the intention of the proposal.  Firstly, some modifications as following:   * **Tx timing error**: From signal transmission perspective, there will be a time delay from 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 normally needs to implement the internal calibration/compensation of the Tx time delay when it transmits the DL PRS/UL SRS signals. The compensation may also possibly consider the offset of the Tx antenna phase center to the antenna center. However, the calibration may not be perfect. The remaining, uncalibrated Tx time delay is called as *Tx timing error*. * **Rx timing error**: From signal reception perspective, there will be a time delays from time when the RF signal arrives the Rx antenna to the time when the signal is digitized and time-stamped at baseband. For supporting positioning, the UE/TRP normally needs to implement internal calibration/compensation of the Rx time delay before it reports the measurements that are obtained from the DL PRS/UL SRS signals. The compensation may also possibly consider the offset of the Rx antenna phase center to the antenna center. However, the calibration may not be perfect. The remaining uncalibrated Rx time delay is called as Rx timing error. * **UE Tx ‘timing error group’ (UE Tx TEG):** A UE Tx TEG is associated with the transmission of one or more UL SRS resources for positioning purpose, which have the same Tx timing errors within a certain margin. * **TRP Tx ‘timing error group’ (TRP Tx TEG):** A TRP Tx TEG is associated with the transmission of one or more DL PRS resources, which have the same 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 same 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 same 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 positioning purpose, which have the same ‘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 same ‘Rx timing errors+Tx timing errors’ within a certain margin.   Besides, just like the comments in the online session, we think many evaluation results of gNB/UE TX/RX timing errors in TR38.857 (e.g. in Table B.1-1 and Table B.1-2) are inter- gNB/TRP TX/RX timing errors other than the definition here. So, how to deal with those evaluation results if the above definition is agreed upon?,  In addition, regarding synchronization error, we are also confused with its definition and not sure whether synchronization error has been clearly defined in the spec, can companies show the definition in spec? |
| CATT | Support. In our point of view, it is important for the group to have the common understanding/consensus on the definition of Tx timing error, Rx timing error, Tx TEG and Rx TEG, which is the base for the furher discussion. |
| OPPO | 1. The calibration can be done when it is manufactured, i.e.. offline calibration. However, the current wording indicates the calibration procedure is done when it transmits the DL PRS/UL SRS signals. Moreover, the calibration procedure may or may not exist. Thus we suggest to revise the wording to avoid any potential confusion   * **Tx timing error**: From signal transmission perspective, there will be a time delay from 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 ~~normally needs to~~ may implement the internal calibration/compensation of the Tx time delay for the transmission of ~~when it transmits the~~ DL PRS/UL SRS signals. The compensation may also possibly consider the offset of the Tx antenna phase center to the antenna center. However, the calibration may not be perfect. The remaing, uncalibrated Tx time delay is called as *Tx timing error*. * **Rx timing error**: From signal reception perspective, there will be a time delays from time when the RF signal arrives the Rx antenna to the time when the signal is digitized and time-stamped at baseband. For supporting positioning, the UE/TRP ~~normally needs to~~ may implement internal calibration/compensation of the Rx time delay before it reports the measurements that are obtained from the DL PRS/UL SRS signals. The compensation may also possibly consider the offset of the Rx antenna phase center to the antenna center. However, the calibration may not be perfect. The remaing uncalibrated Rx time delay is called as Rx timing error.   2. A lots of proposals are based on the concept of TEG. If we agree some proposal(s) in the future, we should clearly know whether/how the concept can be used for practical products. Thus, if we agree to introduce these concepts for discussion, we suggest to send an LS to RAN1 and ask for the value of margin and feasibility of UE/TRP. |
| ZTE | In the last 2 bullets, taking multi-RTT as an example, the UE Rx-Tx time difference measurements are perturbed by the UE Rx timing errors(when receiving PRSs) and UE Tx timing errrors(when sending SRSs), the situation is the same at TRP side.  So we suggest to change the last 2 bullets as:   * **UE RxTx ‘timing error group’ (UE RxTx TEG):** A UE RxTx TEG is associated with one or more UE Rx-Tx time difference measurements, or, one or more DL measurements and one or more UL SRS resources for positioning purpose, which have the same ‘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, or, one or more UL measurements and one or more DL PRS resources, which have the same ‘Rx timing errors+Tx timing errors’ within a certain. |
| Huawei/HiSilicon | We failed to understand the movitation of introducing RxTx TEG for RTT positioning, as explained in section 3.6. |
| LG | We have two comments. Firstly, we do not see the necessity to additionally consider RxTx TEG, which is described in the last two bullets.  Second, in the current description, it seems that Rx timing error means only the remaining Rx time delay. Even if the calibration/compensations is not done, the definition should include it, since the calibration/compensation of the timing error is up to implementation and/or capability. We suggest to change “normally needs to” as “may” or “may or may not”. Also, we suggest a change of the last sentence as follows: The remaining or uncalibrated Rx time delay is called as Rx timing error. We have the same view on the TX timing error. |
| Fraunhofer | Support. Some non-critical modifications on the definition:  • Tx timing error: From signal transmission perspective, there will be a time delay from 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 ~~normally needs to~~ may implement ~~the~~ an internal calibration/compensation of the Tx time delay when it transmits the DL PRS/UL SRS signals. The compensation may also possibly consider the offset of the Tx antenna phase center to the antenna reference point ~~center~~. However, the calibration may not be perfect. The remaining uncalibrated Tx time delay is called as Tx timing error.  • Rx timing error: From signal reception perspective, there will be a time delays from time when the RF signal arrives the Rx antenna to the time when the signal is digitized and time-stamped at baseband. For supporting positioning, the UE/TRP ~~normally needs to~~ may implement an internal calibration/compensation of the Rx time delay before it corrects/reports the measurements that are obtained from the DL PRS/UL SRS signals. The compensation may also possibly consider the offset of the Rx antenna phase center to the antenna reference point ~~center~~. However, the calibration may not be perfect. The remaining uncalibrated Rx time delay is called as Rx timing error. |
| FL | For MTK’s comments:   * The proposed changes look good in my view.   For vivo’s comments:   * The proposed changes look good in my view. * For inter- gNB/TRP TX/RX timing errors, I assume can be simply defined as the difference of the gNB/TRP TX/RX timing errors between TRPs * For synchronization error, my understanding is that 3GPP has so far not defined time synchronization requirement for positioning purpose.   For OPPO’s comments:   * The proposed changes look good in my view. * About the proposal to send LS to RAN4, yes, I assume RAN1 should keep RAN4 informed on the discussion related Rx/Tx timing errors.   For ZTE’s comments:   * It is uncleat to me why adding “or, one or more DL measurements”. In this definition, we only discuss the definition for “UE Rx-Tx time difference measurements. Does ZTE suggest including other DL measurements (e.g., RSTD)?   For HW’s comments:   * QC has provided some explanation under the discussion of Proposal 3-6a/b. My understanding is that sometimes, it would be easier to calibrate “Rx+Tx” timing errors, but more difficult to calibrate “Rx” and “Tx” timing errors separately.   For LG’s comments:   * For LG’s first comment about RxTx, please see my response to HW’s comments. * For LG’s other comments on the change of the text, yes, I will take them into consideration when updating the proposal.   For Fraunhofers’ comments:   * The proposed changes look good in my view.   Based on the comments, I made some changes to the proposal 3-1 (please see tracked changes). |
| Nokia/NSB | We support the updated proposal. |
| Huawei/HiSilicon | Regarding change “The compensation may also possibly consider the offset of the Tx antenna phase center to the antenna reference point.”, in our view, the Tx antenna phase center should be the actual antenna reference point, and the current wording may be misleading. I are OK with what Nokia used in their t-doc (not in the figure), e.g. physical ARP to denote the antenna center (not ARP).  We have the following suggestion:   * **Tx timing error**: From signal transmission perspective, there will be a time delay from 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 when for the transmission of the DL PRS/UL SRS signals. 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 after calibration , or uncalibrated Tx time delay is defined as *Tx timing error*. * **Rx timing error**: From signal reception perspective, there will be a time delays from time when the RF signal arrives the Rx antenna to the time when the signal is digitized and time-stamped at 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. 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 after calibration, or uncalibrated Rx time delay is defined as Rx timing error. |
| FL | For HW’s comments:   * It seems reasonable to use “physical antenna center” than “antenna reference point”. The proposal 3-1 is modified with the consideration of the comments. |
| ZTE | To FL, sorry for the confusion. We think current wording is not clear for **RxTx TEG**. In our understanding, the RxTx TEG should be the association of DL PRS resources and SRS resources, but the current wording seems to link the “Rx-Tx time difference measurements” and “ PRS resources”. It’s not a right definition. So, we propose to make some revisions:   * **UE RxTx ‘timing error group’ (UE RxTx TEG):** A UE RxTx TEG is associated with one or more DL measurements ~~UE Rx-Tx time difference measurements~~ and one or more UL SRS resources for positioning purpose, which have the same ‘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 UL measurements ~~gNB Rx-Tx time difference measurements~~ and one or more DL PRS resources, which have the same ‘Rx timing errors+Tx timing errors’ within a certain margin. |
| Apple3 | Based on this definition, the error is the residual error (after compensation or wo compensation). Question is which entity knows about this error so it can put different (for example) DL-PRS transmissions under a same (or different) groups? If (for example) gNB/TRP knows about the error, then why it doesn’t try to eliminate it? As commented before, instead of focusing on this “grouping”, in our view we can just consider association of transmission/reception and beam/panel ID. |
| FL | For ZTE’s comments:   * The measurement accuracy of UE Rx-Tx time difference measurements is impacted by both UE Rx timing errors and UE SRS Tx timing error. That is why the definition says UE RxTx TEG is associated with UE Rx-Tx time difference measurements. For ZTE’s proposed change from “UE Rx-Tx time difference measurements” to “DL measurements”, it is unclear to me which DL measurements (except UE Rx-Tx time difference measurements) will be associated with both UE Rx and Tx timing errors. Maybe ZTE can further explain the reason for the proposed changes?   For Apple’s comments:   * The assumption is UE/gNB may not know the timing errors but have the information on how to know how to associate the TEGs, e.g., DL-PRS transmissions with the same or different TRP Tx TEGs, e.g., based on the knowledge of RF chains/antenna panels. Directly associate the Rx and Tx timing errors to beam/panel ID may not be convenient for the reasons we discuss before, e.g., one may argue different Tx antenna panels may have the same Tx timing errors, etc. |
| China Telecom | We support the proposal with companies and FL’s update. Just a little comment, for TxRx TEG, do we need to clarify that the same ‘Rx timing errors +Tx timing errors’ doesn’t mean both the Rx/Tx timing error should be the same. |
| Ericsson | We made some comments in last online that are not captured in the above (please see chairman’s [notes](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/Havish_sessions/Chairman's%20Notes%20RAN1%23104-e%208.5%20v002.doc) ). We’ve added these changes back on top of Huawei’s version with change marks below. With regards to including ‘offset of the Tx antenna phase center’ and ‘offset of the Rx antenna phase center’, we think more discussion is needed before we include these as part of Tx/Rx timing error. Hence, we suggest to place these under brackets for now.   * **Tx timing error**: From signal transmission perspective, there will be a time delay from 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 relative Tx time delay between different RF chains in the same UE/TRP when it transmits the DL PRS/UL SRS signals. [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 calibration , or uncalibrated Tx time delay is defined as *Tx timing error*. * **Rx timing error**: From signal reception perspective, there will be a time delay from time when the RF signal arrives the Rx antenna to the time when the signal is digitized and time-stamped at baseband. For supporting positioning, the UE/TRP may implement an internal calibration/compensation of the relative Rx time delay between the different RF chains in the same UE/TRP before it reports the measurements that are obtained from the DL PRS/UL SRS signals. [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 calibration, or uncalibrated Rx time delay is defined as Rx timing error. |
| ZTE | Thanks for FL’s patient reply and sorry for the misunderstanding of the last 2 bullets. We are fine with the proposal now. |
| vivo 2 | To FL  For our second question in the previous reply, that is, we worried about the validity of evaluation results of gNB/UE TX/RX timing errors in TR38.857 (e.g. in Table B.1-1 and Table B.1-2). We conclude the agreement that the gNB/UE TX/RX timing errors need to be mitigated because of the evaluation results. But now, we redefine the gNB/UE TX/RX timing errors which only focus on the internal gNB/UE TX/RX timing errors, we concern about whether we can reach the same conclusion.  Table B.1-1: Summary of evaluated gNB/UE TX/RX timing error parameters and achieved horizontal positioning accuracy in InF-SH baseline scenario for Rel.16 positioning method.   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | Company name  (Positioning method) | FR1 / FR2 | gNB/UE TX/RX timing error mitigation is on/off | Evaluated UE TX/RX timing error values (Y value) | Evaluated gNB TX/RX timing error values (X value) | Is horizontal positioning accuracy  0.2m @ 90% met? | Is horizontal positioning accuracy  0.5m @ 90% met? | | [10]  (Multi-RTT) | FR1 | Off at gNB  Off at UE | 10 ns | 5 ns | NO | NO | | FR1 | Ideal at gNB  On at UE | 0 ns | 5 ns | NO | YES | | [7]  (DL-TDOA) | FR1 | Off at gNB | 0 ns | 0.5 ns | NO | NO | | FR2 | Off at gNB | 0 ns | 0.5 ns | NO | YES | | [4]  (DL/UL-TDOA) | FR1 | Off at gNB | N/A | 1.4ns  (2ns inter-gNB difference) | NO | NO | | [4]  (UL-TDOA/AoA) | FR1 | Off at gNB | N/A | 1.4ns  (2ns inter-gNB difference) | NO | YES | | [4]  (Multi-RTT) | FR1 | Off at gNB  Off at UE | 5.6ns  (8ns intra-UE Rx - Tx difference) | 1.4ns  (2ns intra-gNB Rx – Tx difference) | NO | NO | | [4] (UL-TDOA) | FR1 | On at gNB | N/A | 0ns inter-gNB difference | YES | YES | | 0.2ns inter-gNB difference | YES | YES | | 0.5ns inter-gNB difference | NO | YES | | 1ns inter-gNB difference | NO | NO | | [5]  (DL-TDOA) | FR1 | Off at gNB  Off at UE | 0 ns | 0 ns | YES | YES | | 0.5ns | 0.5ns | NO | YES | | 1ns | 0.5ns | NO | YES | | 2ns | 0.5ns | NO | YES | | 3ns | 0.5ns | NO | YES | | 5ns | 0.5ns | NO | YES | | 0.5ns | 1ns | NO | YES | | 0.5ns | 2ns | NO | NO | | 0.5ns | 3ns | NO | NO | | 0.5ns | 5ns | NO | NO | | [5]  (Multi-RTT) | FR1 | Off at gNB  Off at UE | 0 ns | 0 ns | YES | YES | | 0.5ns | 0.5ns | NO | YES | | 1ns | 0.5ns | NO | YES | | 2ns | 0.5ns | NO | YES | | 3ns | 0.5ns | NO | YES | | 5ns | 0.5ns | NO | YES | | 0.5ns | 1ns | NO | YES | | 0.5ns | 2ns | NO | YES | | 0.5ns | 3ns | NO | NO | | 0.5ns | 5ns | NO | NO | | [17]  (DL-TDOA) | FR2 | Off at gNB  Off at UE | 0.0ns | 0.0ns | YES | YES | | 0.1ns | 0.1ns | YES | YES | | 0.2ns | 0.2ns | YES | YES | | 0.5ns | 0.5ns | NO | YES | | 1.0ns | 1.0ns | NO | NO | | 2.0ns | 2.0ns | NO | NO | | [20]  (DL-TDOA) | FR2 | Off at gNB  Off at UE | N/A | 0ns | YES | YES | | Off at gNB  Off at UE | N/A | 1ns | NO | YES | | Off at gNB  Off at UE | N/A | 2ns | NO | NO | | Off at gNB  Off at UE | N/A | 4ns | NO | NO | | Off at gNB  Off at UE | N/A | 8ns | NO | NO | | On at gNB | N/A | 0ns | YES | YES | | On at gNB | N/A | 8ns | YES | YES | |
| Huawei/HiSilicon | To vivo, in our understanding focusing on intra-gNB TEG during WI is because we think intra-gNB TEG may have further specification impact, while different TRPs should of course fall into different TEG, which is natural without any specification impact, i.e. we do not need to define signalings and procedures to support different TRPs identified in the same TEG. |
| FL | For China Telecom’s comments:   * I assume people understand “the same ‘Rx timing errors +Tx timing errors’ doesn’t mean both the Rx/Tx timing error should be the same. We could add (The same ‘Rx timing errors+Tx timing errors’ does not mean the same Rx timing errors and the same Tx timing errors if necessary.   For Ericssson’s comments:   * When UE/gNB implements the internal calibration/compensation, I assume it needs to first consider the Rx/Tx time delays for each RF chain, since they are, in general, much larger than relative Tx/Rx time delays between RF chains. * UE/gNB may need to implement the internal calibration/compensation even with a single RF chain/antenna panel. * UE/TRP may implement additional calibration/compensation on the relative Tx/Rx time delays for higher accuracy requirements. Thus, my thinking is that we will add the description of calibration of the relative Tx/Rx time delays instead of replacing the calibration/compensation on the Tx/Rx time delays. * Thus, I would suggest the following changes to address the comments:   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.  For vivo’ and HW’s comments:   * I assume vivo’s concern is valid. I would suggest we focus on inter-TRP for now. We may continue if we could extent to the definitions to inter-TRP cases with the WI scope. |
| Nokia/NSB\_2 | We are okay with Huawei’s proposed update.  We don’t understand Ericsson’s concern and proposal to add brackets around the phase center parts. We are working on a definition of what the timing delays are, which we aim to mitigate. We are not yet agreeing to specify anything. The phase center offsets do impact the timing, that is simply a fact. We can debate the need to add specification effort to address them or if the impact is small enough to ignore but to have a definition without them would just not be correct in our view. |
| Intel | OK.  We also suggest replacing the “TRP” with the “TRP/gNB” in the text proposal and error types definition. |
| FL | For Ericsson, HW, FhG and NOK’s discussion on the phase center offsets:   * Suggest using “physical antenna center” instead of “antenna center” for clarity; * It seems no need to add brackets around the phase center parts unless there is a special concern on it.   For Intel’s comments:   * It seems fine to replace “TRP” with “TRP/gNB”. We can bring this up in online session. |

FL comments

The discussion is closed. See Chairman’s note for the agreement.

## Mitigating gNB Tx timing errors (for RSTD and DL positioning)

FL comments

DL measurement accuracy (e.g., RSTD) may be impacted by TRP Tx timing errors. When a UE measures the DL PRS and reports the DL PRS measurements, the UE may not have the information of the TRP Tx timing errors, and thus may not be able to mitigate the gNB Tx timing errors when reporting the DL PRS measurements. Multiple companies (e.g., [1][3][4][5][8][11][13][14][17]) propose to support TRP provide the TRP Tx timing errors to LMF and UE (UE-based positioning) to mitigate the gNB Tx timing errors. gNB Tx timing errors may be different for different antennal panels/RF trains. Thus, there can be multiple gNB Tx timing error groups for a TRP, and each TEG may be associated with one or more DL PRS resources. As an alternative, another proposal is for LMF to provide the differences of the gNB Tx timing errors of TEGs and/or TRPs to UEs.

Proposal 3-2a

* Support a TRP to provide the association information of Tx TEGs with DL PRS resources to LMF.
* FFS: details of signalling and procedures

Comments

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| **Company** | **Comments** |
| MTK | 1, “Support a TRP to provide Tx timing errors per Tx TEG to LMF” 🡨 Can the rapporteur explain the “timing error” here is the statistics of the error? Or actually the timing delay? |
| vivo | Same views as proposal 3-1. Whether different TEG can be seen in a TRP needs to be discussed first.  Because in our understanding, at least in positioning, one TRP will not deploy more than one antenna panel. Therefore, there will not be multiple groups of ‘Rx/Tx timing delay’ in R17 scope. |
| Huawei/HiSilicon | We do not think the TEG concept has any relevance to the gNB.  For TRP to provide association information, we think the baseline should be OK that all the DL PRS resource sets of a TRP (on a single positioning frequency layer or across multiple positioning frequency layers) should be corresponding to the same “TEG”, which is reflected by the SFN initialization time.  For TRP to provide Tx timing errors per Tx TEG, we also do not think it is needed, as if the error is already known or estimated by the TRP, TRPs can do compensation on its own, ensuring the existing SFN initialization time is valid. |
| CMCC | We are fine with the first bullet.  For the 2nd bullet, in our views, whether to support TRPs to provide Tx timing errors per Tx TEG or not depends on which method is used to mitigate the timing delays. As proposed by proposal 2-3/4, if TRP/reference UE is enabled, then the impact of gNB Tx timing delay difference can be estimated and compensated by the LMF, and therefore no need for the TRP to report its Tx timing error to the LMF. We should decide which mitigation methods will be supported and specified first, and then further discuss detailed information to be provided and exchanged. |
| CATT | Support. |
| FL | For MTK’s comments, the assumption is that there are remaining Tx/Rx errros after the manufacture calibration. The remaining Tx/Rx errros may be random, but biased, and may or many not be further calibrate and/or estimated for improving the positioning performance. One of the purpose of define TEG is to indicate the measurements may be impacted by different timing errors in case different antenna panels with different trains are used for measurements.  For vivo, it is correct that only single TXRU is used as baseline simulation assumption. The issue here is whether in a practical implementation, UE/gNB will always use a single TXRU.  For HW’s comment, yes, the definition of the term is used mainly for the purpose of discussion and potential agreement. |
| Qualcomm | From the beginning of the SI, we added timing errors in both UEs and gNBs. I don’t understand why we now say that the gNBs can ensure that all PRS resources have the same exact timing?  Each PRS resource may have its own geographic location (as already supported in the spec), and therefore they can have their own timing, if indeed the PRS resources are not collocated. Allowing PRS resources to not be collocated is already in the specification.  Assistance data and configuration have in NR Rel-16 a single timing, which is clearly a simplification that was done in NR rel-16. Focusing only on UE errors will not make this discussion to be a “fair” and “constructive” approach of addressing the timing errors and will not be following the intention of the writing of the WID. Discussion on how to mitigate gNB and UE errors should progress in a similar pace. |
| Nokia/NSB | Similar to HW we feel that if the TRP is able to determine the Tx error itself then it should be able to also just correct it locally. Could any proponent explain why this requires signalling? |
| Ericsson | We are ok with the first bullet. But, regarding the second bullet, we agree with other companies that it is not necessary for the TRP to provide the Tx timing errors to the LMF. It is enough to define the TEG and for the TRP to include the TEG index corresponding to DL PRS resources to the LMF. So we do not suppor the 2nd bullet. |
| Fraunhofer | The TRP may be able to determine a delays with an uncertainty. It might be better in such scenario to provide the LMF or UE with the information, or the timing error can be the uncertainty information.  Support the second bullet with the following modification:   * Support a TRP to provide PRS timing errors to LMF. |
| Apple | The intention is not quite clear (at one hand if TRP is able to determine the Tx error itself then it shall come up with compensation, on the other hand we support a mechansime in which the TRP Tx error is available at LMF, and/or UE). Maybe the proposal should be from the view point of LMF and/or UE in terms of having access to TRP Tx error. Now how this error is determined is a separate discussion (e.g. it could be through reference entity, or TRP report!) |
| China Telecom | We support the first bullet.  For the second bullet, we have similar wih other companies that it may not be necessary for the TRP to provide Tx timing errors to the LMF. |
| OPPO | All the proposals in Section 3 are based on the reporting/indication of information of Tx/Rx TEGs. It is preferred to discuss as the first step that  1. whether / how Tx/Rx TEG is defined  2. In what conditions the reception/transmission can be regarded with the same Tx/Rx TEG  If we address the above issue, we can apply the agreement for each positioning methods directly with some potential modification. If we cannot agree on the above issues, it seems difficult to make progress for the proposes 3-x. |
| ZTE | We think that the granularity of dividing TRPs to different TEGs are too small. We agree with HW that all the DL PRS resource sets of a TRP should be corresponding to the same “TEG”,so multiple TEG within a TRP are not necessary. As for the second bullet, how to measure the Rx or Tx timing errors per TRP or Tx/Rx timing errors between TRPs needs further discussion. |
| LG | We are open to discuss the necessity of the first bullet, but we have the same view with other companies on the second bullet, which is not necessary. If the TRP knows the error terms, the TRP simply cancel it from the measurement. |
| FL | Based on the comments, most companies do not think it is necessary to have the 2nd bullet, but support to have the 1st bullet. Some companies also think there is no need to have the 1st bullet, which can be further discussed after we discuss Proposal 3-1. |
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Proposal 3-2b

* Support LMF to provide the association information of Tx TEGs with DL PRS resources to a UE for UE-based positioning.
* Support LMF to provide the Tx timing errors of a TRP per TEG to a UE for UE-based positioning
  + FFS: Support LMF to provide the difference of Tx timing errors between a TEG (of a TRP) and a reference TEG (of a reference TRP), to a UE for UE-based positioning
* FFS: details of signalling and procedures

Comments

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| **Company** | **Comments** |
| vivo | In general, we can understand FL's intention. But we think it should be discussed after the understanding, method, and mechanism are clear. |
| Huawei/HiSilicon | If this discussion is about resource-specific RTD, we do not think that it should be a typical use case, as PRS resources from the same PRS resource set are supposedly transmitted from the same Tx chain, and the necessity of further refinement on the resource-specific RTD is still in question. Note that Rel-16 UE-based assistance data already supports RTD per TRP per frequency layer.  NR-RTD-Info-r16 ::= SEQUENCE {  referenceTRP-RTD-Info-r16 ReferenceTRP-RTD-Info-r16,  rtd-InfoList-r16 RTD-InfoList-r16,  ...  }  ReferenceTRP-RTD-Info-r16 ::= SEQUENCE {  dl-PRS-ID-Ref-r16 INTEGER (0..255),  nr-PhysCellID-Ref-r16 NR-PhysCellID-r16 OPTIONAL, -- Need ON  nr-CellGlobalID-Ref-r16 NCGI-r15 OPTIONAL, -- Need ON  nr-ARFCN-Ref-r16 ARFCN-ValueNR-r15 OPTIONAL, -- Need ON  refTime-r16 CHOICE {  systemFrameNumber-r16 BIT STRING (SIZE (10)),  utc-r16 UTCTime,  ...  },  rtd-RefQuality-r16 NR-TimingQuality-r16 OPTIONAL, -- Need ON  ...  }  RTD-InfoList-r16 ::= SEQUENCE (SIZE (1..nrMaxFreqLayers-r16)) OF RTD-InfoListPerFreqLayer-r16  RTD-InfoListPerFreqLayer-r16 ::= SEQUENCE (SIZE(1..nrMaxTRPsPerFreq-r16)) OF RTD-InfoElement-r16  RTD-InfoElement-r16 ::= SEQUENCE {  dl-PRS-ID-r16 INTEGER (0..255),  nr-PhysCellID-r16 NR-PhysCellID-r16 OPTIONAL, -- Need ON  nr-CellGlobalID-r16 NCGI-r15 OPTIONAL, -- Need ON  nr-ARFCN-r16 ARFCN-ValueNR-r15 OPTIONAL, -- Need ON  subframeOffset-r16 INTEGER (0..1966079),  rtd-Quality-r16 NR-TimingQuality-r16,  ...  } |
| CATT | Support. |
| InterDigital | Support |
| Qualcomm | Support.  Same reply as above which I repeat for the record:   * From the beginning of the SI, we added timing errors in both UEs and gNBs. I don’t understand why we now say that the gNBs can ensure that all PRS resources have the same exact timing? * Each PRS resource may have its own geographic location (as already supported in the spec), and therefore they can have their own timing, if indeed the PRS resources are not collocated. Allowing PRS resources to not be collocated is already in the specification. * Assistance data and configuration have in NR Rel-16 a single timing, which is clearly a simplification that was done in NR rel-16. Focusing only on UE errors will not make this discussion to be a “fair” and “constructive” approach of addressing the timing errors and will not be following the intention of the writing of the WID. Discussion on how to mitigate gNB and UE errors should progress in a similar pace.   One more addition:  Actually, It would have been simpler, even in proposal 3-2a to just change “report to the LMF”, to “report to the LMF or UE”. If a report exists to help UE-A gNB timing errors, it should also have a corresponding report to help UE-B TDOA. |
| Nokia/NSB | Similar comment as on Proposal 3-2a. |
| Ericsson | Similar comment as Proposal 3-2a. We do not support the second bullet. Providing TEG index with DL PRS resources from the LMF to the UE should be enough. No need to provide the Tx timing errors between TEGs. |
| Fraunhofer | Support the second bullet with the following modification:   * Support LMF to provide the PRS timing errors to a UE for UE-based positioning |
| Apple | Similar comment as on Proposal 3-2a. |
| Huawei/HiSilicon | To QC:  In our understanding  1. Resource-specific ARP does not necessarily lead to resource-specific RTD, because the TRP can do the compensation to unify the TRP specific RTD, as TRP is aware of the resource-specific ARP, if different from the TRP ARP.  2. TRP should always try its best to compensate the Rx/Tx error to its knowledge, while LMF may access additional delay information beyond the knowledge of TRP, e.g. through calibration that is transparent to the TRP, so the information that may be transported between TRP and LMF may be different from between LMF and UE (for UE-based positioning). |
| China Telecom | Similar comment as Proposal 3-2a. We support the first bullet. |
| ZTE | Similar view as comments on proposal 3-2a that, We think that the granularity of dividing TRPs to different TEGs are too small. |
| LG | Similar comment as Proposal 3-2a. |
| FL | Based on the comments, it seems it would be better for us to first discuss Proposal 3-2a and then further discuss Proposal 3-2b. |

Proposal 3-2 (Revision 1)

Consider 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 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
* FFS: details of signalling and procedures
* **Note**: Depending on the discussion results, none/one/multiple of above options may be adopted in Rel-17.

Comments

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| **Company** | **Comments** |
| vivo | Just like FL views (Different Tx RF chains/panels may have different RF delays.) in proposal 3-1. We can’t agree with this description like “Tx timing errors per TEG of TRP”.  We prefer to modify as follows to ensure that more solutions are not excluded  Consider 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 or Tx timing errors difference ~~per Tx TEG~~of one or multiple TRP(s) to LMF * Option 4:   + Support LMF to provide the Tx timing errors or Tx timing errors difference ~~per Tx TEG~~of one or multiple TRP(s) ~~per 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 * FFS: details of signalling and procedures * FFS: TEG of a TRP * **Note**: Depending on the discussion results, none/one/multiple of above options may be adopted in Rel-17. |
| Huawei/HiSilicon | We failed to see the need for a node to ~~support~~ report its own timing error to a third party, which means that option 4 should ~~not~~ be excluded.  For others, currently we do not have preference over TEG at TRP side, as we do not think a single TRP is likely to have multiple TEGs for indoor environment, and even if so, we can split the TRP into multiple TRPs, but we are fine to currently include the options.  Regarding comments from revision from vivo, we are not clear why a TRP can provide Tx timing error difference of one (other) or multiple TRPs in Option 3, and we think existing RTD in UE-based assistance data already supports the modified Option 4. |
| CATT | Support. We prefer Option 1+2+3+4. Tx TEG in TRP should be reported to LMF(UE-assisted positioning) or UE(UE-based positioning), since Tx TEG in TRP is more important and Rx timing delay error may be compensated in UE side. |
| LG | We think that it is too early to introduce this functionality and we need further discussion on whether the concept of TEG needs to be introduced or not. We prefer to discuss separately TRP timing errors and UE RX timing errors.  At first, for the TRP, indoor factory scenario, is it usual case to deploy TRP which is equipped with multiple panels? In addition, even if we assume the TRP with multiple panels, we need to check if it is possible to calibrate and compensate its group delay by the TRP. For the UE, we think that RSTD measurement could be done by using the same reception panel. It is unclear that it is really too restrictive to achieve the target performance. Also, if we assume that the UE performs RSTD measurement across reception panels, it is necessary to check if the UE can compensate by itself the group delay. In the current phase, we prefer to firstly define the terminology for the technical discussion, and discuss the necessity. |
| FL | To vivo: For the suggested modification for Option 3, it is unclear to me how one TRP can have the Tx timing error difference information. Is the suggestion for one TRP to monitor the Tx time of another TRP? For Option 4, I have the same understanding as HW that sending RTD between TRPs to UE was already supported in Rel-16. For the comment include TRP TEG as FFS, |
| Qualcomm | We prefer to write all the options as shown by FL.  To HW: HW’s view that sending the timing errors is not needed is clear, thanks for the technical discussion. However, we can debate on this during the next meetings. Is it so important to exclude the technical discussion from the first meeting? There is a note that says that none or some of the options may be supported. Also, this proposal says: “Consider the following options”; so there is not really agreements here; just laying down the groundwork of what we should do during this year. We think it’s the right way of approaching the problem, and trying to build-up consensus slowly 😊. |
| Nokia/NSB | We are okay to list the options as written by FL. |
| Apple | We are OK with the intention, although we still a better way could be instead of grouping of errors just report based on source of error. For example, instead of TRP reporting this PRS transmission belong to which TEG, it just simply indicate the transmission panel, etc. That should be anyway more accurate and we don’t need to talk about margins etc… |
| Ericsson | We assume the intention here is to downselect among these options which seems to be the case in the last note.  We support Options 1, 2 and 5 only.  As we commented above, it is enough for the TRP to include the TEG index corresponding to DL PRS resources to the LMF. We do not see the need for TRP to send to send the Tx timing errors to LMF, hence we do not support Option 3.  Similarly, Providing TEG index with DL PRS resources from the LMF to the UE should be enough. There is no need to provide the Tx timing errors per TEGs of TRP to a UE, hence we do not support Option 4. |
| FL | For Apple’s comments, the issue may not be resolved by simply reporting the antenna panel and/or RF chain, since one may argue that in some cases the measurements from the different antenna panels may have the same Tx/Rx timing errors (if the device has the capability to have self-calibration), and in other cases, the measurements from the different antenna panels may have the different Tx/Rx timing errors from different PRS/SRS resources, or even different AOAs (e.g., phase center offset). |
| InterDigital | We support the FL’s proposal. |
| OPPO | Regarding Option.3/4, one question for clarification. If TRP can know the Tx timing error, why does UE not compensate it? |
| CMCC | From the current stage, we are OK to keep all these options as proposed for further discussion. In addition, we are also fine with the revision of Option 3 proposed by vivo, we think it is applicable to the case when the reference device is a TRP, which can estimate the Tx timing error difference from other TRPs. |
| China Telecom | We support the proposal in general. And we prefer option 1+2 at this stage, but also open for further discussion on Option 3,4,5. |
| vivo2 | Thanks for the reply with Huawei and FL, We think we misunderstood the Tx/Rx timing error in the previous reply, which is an INTERNAL error and doesn’t include the Tx/Rx timing error of Multiple TRPs.  If the above understanding is right, we are okay with the FL proposal for the first discussion.  And we have another question for symmetry: Should the UE side have option 6 correspond to option 4 on the network side? For example, if the Rx timing error of UE can be calculated by AoA and other timing-based positioning, or other methods in LMF, can LMF provide the Rx timing error to help UE mitigate Rx Timing error?   * Option 6:   + Support LMF to provide Rx timing errors per Rx TEG to a UE if LMF can obtain Rx timing errors per Rx TEG of UE.   In addition, if including option3, we think ‘UE provide Rx timing errors’ should not be excluded although we have the same understanding that UE and gNB can compensate for themselves if they know.   * Option 7:   + Support a UE to provide Rx timing errors per Rx TEG to LMF for UE-assisted positioning   Otherwise, we should remove both option 3 and option 4. |
| ZTE | We support option5 and agree with vivo’s first modification. As we comment before, a single TRP should have only 1 Tx or Rx timing delays while a single UE can have multiple Tx or Rx timing delays.  To HW and FL: If the RTD value defined in R16 contains synchronization error and Tx group delay difference between different TRPs, option 4 may not be needed; If not, more clarification will be needed of defining RTD in R17. |
|  |  |

Proposal 3-2 (Revision 2)

Consider 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 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-bsed positioning
* Option7:
  + Support a UE to provide Rx timing errors per Rx TEG to LMF for UE-assisted positioning
* FFS: details of signalling and procedures
* **Note**: Depending on the discussion results, none/one/multiple of above options may be adopted in Rel-17.

Comments

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| **Company** | **Comments** |
| Nokia/NSB | We are okay with this proposal is principle but does it not rely on having a definition of TEG first? See also our comments on Proposal 3-1 (revision 2). |
| CATT | Support. We prefer Option 1+2+3+4. Tx TEG in TRP side should be reported to LMF(UE-assisted positioning) or UE(UE-based positioning), since Tx TEG in TRP side may be associated with different RF chains. Moreover, Rx timing delay error may be compensated in UE side. |
| Intel | Support in general the proposal |
| FL | For NOK’s comments, we would suggest first discussing TEG definition in online session. |
|  |  |

Proposal 3-2 (Revision 3)

Consider 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 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
* FFS: details of the signalling, procedures, and UE capability
* 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.

Comments

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| **Company** | **Comments** |
| vivo | Support in principle.  Should we add ‘Rx timing error differences between Rx TEGs’ or‘Tx timing error differences between Tx TEGs’ in Option 3-Option 7 as Option4 in Proposal 3-3?  Besides, considering many companies have concern about the introduction of “TEG of TRP”, therefore, we propose to add an FFS for “TEG of TRP” in an explicit way. |
| ZTE | Firstly, we support option 5.  In addition, during the former discussions, we had a consensus that timing error we are talking about is the the remaining uncalibrated Rx time delay. However if UE has capability to fully calibrate the the remaining Rx time delay, there is no need for UE to report RX timing errors. That is, UE can calibrate its own timing errors locally. However, whether full calibration has been done by UE is a useful information for LMF to conduct positioning. For example this information will refrain LMF from over-calibration. Similar way for TRP side. So, we propose to have another two options,   * Option 8:   + Support a UE to provide the information to LMF that indicates whether the Rx timing errors of RSTD measurements have been calibrated locally within a certain margin. * Option 9:   + Support a 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. |
| Huawei/HiSilicon | OK |
| InterDigital | Support the FL’s proposal |
| LG | To ZTE,  We have a question. In option 8, does it means that the UE reports the information of calibration for each RSTD measurements? We think this is kind of UE capability. If the UE has a capability to compensate timing errors of RSTD measurement (This RSTD may be obtained through different Rx panels), the UE always needs to perform calibration. |
| CATT | Support in principle. We have some concerns on Option 6 ( i.e. Support LMF to provide Rx timing errors per Rx TEG to a UE for UE-bsed positioning). In our understanding, for DL-TDOA method, the Rx TEG in the UE side is related to the Rx RF chain of UE, which should be known for UE, this information may be provided from UE to LMF, but may be not from LMF to UE. |
| FL | For vivo’s comments:   * I assume we could add the options of “Rx timing error differences between Rx TEGs’ and ‘Tx timing error differences between Tx TEGs’ for consideration * About adding “FFS” for “TEG of TRP”, I assume it may not need to do so, since the proposal simply list the proposed options for further discussion. I assume not all of the options will be adopted   For ZTE’s comments:   * I assume both UE and gNB are assumed to calibrate their Tx/Rx timing errors within a certain range to meet potential RAN4 performance requirements by default. I share the similar view as LG the proposal seems related to UE’s capability to meet certain performance requirements. |
| Nokia/NSB | Okay. |
| ZTE | To LG and FL, the “full calibration” in our previous comment means UE/TRP have capability to monitor timing errors precisely, so UE/TRP will compensate/calibrate the reported measurements or pre-compensate them during the RS transmission. Therefore, LMF side doesn’t need to do cancellation/mitigation again. But the status of whether UE/TRP have conducted the compensation on reported measurements or pre-compensation on RS transmission should be informed to LMF. This status will refrain LMF from over-calibration/cancellation/mitigation.  In our understanding, even if UE/TRP has the capability to do the full calibration precisely (or within a certain margin), the UE/TRP may not always have exact timing errors at hand to compensate by itself, according to the following reasons:   1. The full calibration may need UE to interrupt the transmission, although this may be done by implementation. UE may not find a good time occasion to monitor timing errors, so UE may not always compensate/calibrate the reported measurements or pre-compensate them during the RS transmission. 2. Due to the timing error drift , the acquired timing errors may not be effective all the time.   Hope above response clarifies our motivation. At this early stage, it should be fair to list all possible options. |
| Apple3 | Same comment as P3-1 Rev3. For example in Option 1, how does TRP know about a PRS TX TEG, especially considering the error after compensation (based on definition)…Why don’t we just consider report of whatever could be the source of error (like Tx panel ID)? In addition, why UE RX TEG is needed, for RSTD it is cancelled, right? |
| FL | For ZTE’s comments:   * Based ZTE’s description, it seems the proposed option is more or less related to UE/TRP’s capability to monitor/calibration of the timing errors. Since the Proposal 3-2 (Revision 3) are related the TEGs, maybe ZTE’s proposed options can be considered as a separate proposal for discussion.   For Apple’s comments:   * Please see the response to Apple’s comment in P3-1 Rev3. |
| China Telecom | Support the proposal in principle. |
| Ericsson | Ok to study this list from which we can downselect later.  We support Options 1, 2 and 5 only.  As we commented above, it is enough for the TRP to include the TEG index corresponding to DL PRS resources to the LMF. We do not see the need for TRP to send to send the Tx timing errors to LMF, hence we do not support Option 3.  Similarly, Providing TEG index with DL PRS resources from the LMF to the UE should be enough. There is no need to provide the Tx timing errors per TEGs of TRP to a UE, hence we do not support Option 4. |
| ZTE | We agree with FL’s arrangement, and the 2 newly-added proposals related with UE/TRP capability may be discussed with proposal 3-7 together. |
| vivo2 | Firstly, according to our previous suggestions and FL’s reply, maybe we can add a note for ‘Rx timing error differences between Rx TEGs’ or‘Tx timing error differences between Tx TEGs’  Secondly, we think restricting UE only measure/transmit positioning signals with one TEG is also a solution to mitigate the error.  So, we propose: Proposal 3-2 (Revision 3) Consider 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 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 * Option8:   + Support LMF to indicate UE/gNB to use one Rx/Tx TEG for reception/transmission * FFS: details of signalling and procedures * Note: Other options are not precluded. * **Note**: Depending on the discussion results, none/one/multiple of above options may be adopted in Rel-17. * **Note:** Tx/ Rx timing errors may include Tx/ Rx timing error differences between Tx/ Rx TEGs |
| Intel | Support in principle.  Support to study the list of considered options and perform down selection at the next meetings.  We suggest the following changes:  Consider the following options for mitigating TRP/gNB Tx timing errors and/or UE Rx timing errors for DL TDOA:   * Option 1:   + Support a TRP/gNB 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/gNB to provide the Tx timing errors per Tx TEG to LMF * Option 4:   + Support LMF to provide the Tx timing errors per TEG of TRP/gNB 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/gNB to provide the Tx timing errors difference over different Tx TEGs to LMF * FFS: details of signalling and procedures * Note: Other options are not precluded.   **Note**: Depending on the discussion results, none/one/multiple of above options may be adopted in Rel-17. |
| FL | For ZTE’s comments:   * I have created a new proposal 3-2-1 to include the options for further discussion.   For vivo’s comments   * For the proposal to add “Option8: Support LMF to indicate UE/gNB to use one Rx/Tx TEG for reception/transmission”, while I assume this could be an option, there could be other similar options along this line, e.g., “Support LMF to indicate UE/gNB to use N(>1) Rx/Tx TEGs for reception/transmission. It may also be related to UE’s capability on whether it is able to support more than 1 TEG. Since we have the note “Other options are not precluded”, my suggestion is to include the suggested “Option8:” into proposal 3-2-1 together with ZTE’s proposed options for further discussion. * I understand the intention for the suggestion to add “Note: Tx/ Rx timing errors may include Tx/ Rx timing error differences between Tx/ Rx TEGs”. The issue here is for most options we use the wording “timing errors per TEG”. To avoid confusion, my suggestion is to have a new proposal (e.g., Proposal 3-2-2) to include the options to address Tx/Rx timing error differences between Tx/ Rx TEGs. |

FL Comments

Proposal 3-2 (Revision 4) is Proposal 3-2 (Revision 3) with additional options related to timing error differences based on the previous comments. Please take a look to see if there is any additional comments.

### Proposal 3-2 (Revision 4)

Consider 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
* 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.

Comments

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| **Company** | **Comments** |
| Huawei/HiSilicon | Normally we do not think that it is necessary for the node report its internal TEG error (error difference) to another node. In addition, we also do not think listing so many Options will help further discussion. |
| vivo | Support this proposal with minor changes.  For missing of ‘UE providing the Rx timing error differences between Rx TEGs’, we propose to add   * Option10:   + Support a UE to provide Rx timing error differences between Rx TEGs to LMF for UE-assisted positioning   For Option4, Option 8 and Option 9, it seems that ‘Tx’ in the description is missed.   * Option 4:   + Support LMF to provide the Tx timing errors per Tx TEG of TRP to a UE for UE-based positioning * Option 8:   + Support a TRP to provide the Tx timing error~~s~~ 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 |
| CATT | Support in principle. We have some concerns on Option 6 ( i.e. support LMF to provide Rx timing errors per Rx TEG to a UE for UE-based positioning). In our understanding, for DL-TDOA method, the Rx TEG in the UE side is related to the Rx RF chain of UE, which should be known for UE, this information may be provided from UE to LMF, but may be not from LMF to UE. |
| OPPO | We share the same viewas Huawei that a long list of options doesn’t help. Moreover, our intension is not to have a complete list of all posisibile options regardless its feasibility/benefits. We have some specific comments for some options  1. Option 7: If UE knows Rx timing errors per Rx TEG, why doesn’t UE compensate them?  2. Option 6: Could some proponent(s) explain how LMF knows Rx timing errors per Rx TEG at UE side?  3. In some sense, timing error (especially Rx timing error) depends on the hardward. If a UE supporting UE-A positioning can know Rx timing errors per Rx TEG, why cann’t a UE supporting UE-B positioning cannot know that?  3. Similar comments are also applicable to the counterparts for TRP. |
| Intel | Support in principle.  Support to study the list of considered options and perform down selection at the next meetings. |
| FL | For HW, CATT, OPPO’s comments:   * If a receiver (UE or TRP/gNB) knows its Rx timing errors, I would say it is reasonable to assume the receiver should compensate the Rx timing errors. For this meeting, it may be simpler to list the options. Similarly, if a transmitter (UE or TRP/gNB) knows its Tx timing errors, the transmitter should compensate the Tx timing errors. However, for this meeting, we don’t have the time to have a discussion on the options. It may be simpler to list the options. We could simply remove them once we reach a common undertsnading on whether the receiver is responsible for compensating the known Rx timing errors and the transmitter is responsible for compensating the Tx timing errors.   For CAT and OPPO’s comments related to OPPO’s comments related to Option 6:   * I would assume LMF could have UE Rx information in some particular scenarios, e.g., based on the estimation of the UE Rx timing error based on previous measurements.   For vivo’s comments:   * I added Option 10 into the proposal. * The proposed ed changes looks good to me. |
| ZTE | Support in principle for further down selection. |
| Nokia/NSB | We agree with some of the above comments that if a node (UE or TRP) knows the timing errors then it should just compensate them. Since we have defined the errors as residual it doesn’t make much sense to us. That said if we change those options to “estimated” errors then we are okay to agree on optiosn for study. |

FL Comments

Proposal 3-2-1 is a new proposal based on the comments from ZTE and vivo to Proposal 3-2 (Revision 3). Please see the discussion of Proposal 3-2 (Revision 3) for the background of adding Proposal 3-2-1.

### Proposal 3-2-1 (New)

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

* Option 1:
  + Support a UE to provide the information to LMF that indicates whether the Rx timing errors of RSTD measurements have been calibrated locally within a certain margin.
* Option 2:
  + Support a 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.
* Option 3:
  + Support LMF to indicate UE/gNB to use one Rx/Tx TEG for reception/transmission
* FFS: details of signalling and procedures
* Note: Other options are not precluded.
* **Note**: Depending on the discussion results, none/one/multiple of above options may be adopted in Rel-17.

Comments

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| **Company** | **Comments** |
| Huawei/HiSilicon | We do not think it is appropriate to discuss those options.  For example, Option 1 is like the UE capability issue. Option 2 is overlapped with Option 2 from Proposal 3-2. Option 3 does not soud like a 5GC entify behaviour. |
| vivo | We support the proposal because of option 3.  To Huawei  It is noted that LMF already supports transmitting the different information to indicate the action of UE /gNB (eg, SRS frequency information is used to indicate the preferred SRS frequency, or *nr-DL-PRS-RstdMeasurementInfoRequest* to indicate whether the target device is requested to report DL-PRS Resource ID(s) or DL-PRS Resource Set ID(s) used for determining the timing of each TRP in RSTD measurements). So we don’t know why option 3 is not like a 5GC entity behavior. |
| vivo 2 | To Huawei  We can understand your concerns, but as we known, at least in R17 MIMO, gNB indicating UE to use which panel to receive/transmit signal is under discussion. Therefore, we think the similar indication from the LMF can also be considered for positioning and should not be excluded at an early stage. In addition, we make small modifications of option 3 for a more general expression.   * Option 3:   + Support LMF to indicate UE/gNB ~~to use one~~ the use of Rx/Tx TEG for reception/transmission |
| LG | For option 1, the UE does not need to report whether the RX timing erros of RSTD measurements have been calibrated for “each RSTD measurement”. If the UE has the calibration capability, UE can always report the calibrated RSTD measurements.  We have similar view on Option 2  For the purpose of Rx timing error mitigation, we prefer that UE uses single RX TEG for a RSTD measurement where the RX TEG selection is up to the UE. Thus, we suggest to add the following option.  Option 4: UE is not expected to report a RSTD measurement using multiple RX TEGs where the used RX TEG is up to the UE implementation |
| CATT | We prefer to let proposal 3-2-1 (New) as low priority in this meeting. |
| OPPO | Option 1: Not support. It has been included in Option 5 of Proposal 3-2(Revision 4)  Option 2: Not support. It has been included in Option 1 of Proposal 3-2(Revision 4)  Option 3: Not support. We don’t think it is a proper for LMF to control the activation/deactivation of UE’s panel |
| Intel | Support in principle. |
| ZTE | Support the proposal.  To Huawei’s comments:  We agree with you that option 1 and option 2 are related to UE capability, this is why FL proposed this new proposal . But Option 2 here is different from Option 2 in Proposal 3-2. We assume UE has capability to monitor the timing errors, however, the UE may not always have exact timing errors at hand as explained in our previous comment.  To LG’s comments:  Even if UE has the capability to almost fully calibrate timing errors, UE may not do the calibration all the time, due to the following reasons:  1)The full calibration may need UE to interrupt the transmission, although this may be done by implementation. UE may not find a good time occasion to monitor timing errors, so UE may not always compensate/calibrate the reported measurements or pre-compensate them during the RS transmission.  2)Due to the timing error drift , the acquired timing errors may not be effective all the time.  To OPPO’s comments:  This proposal is different from proposal 3-2. We assume UE has capability to monitor the timing errors, however, the UE may not always have exact timing errors at hand as explained in our previous comment.  To all, as main bullet is entitled with “consider”, which means interested companies can further study all the possible options. Therefore, at the early stage of this WI, we think it’s reasonable to have this proposal. |
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## Mitigating gNB Rx timing errors for UL RTOA

FL comments

RTOA measurement accuracy may be impacted by TRP Rx timing errors. Some companies (e.g., [1][8]) propose to support a TRP to provide its Rx timing errors to LMF for UL positioning. However, some others consider there is no need for a TRP to provide its Rx timing errors to LMF, since if a TRP already knows the Rx timing errors, it can/should mitigate the Rx timing errors before report the measurements to LMF(e.g.,[14]). If the TRP does not know the Rx timing errors, one potential solution is to support TRP to provide association information of the RTOA with Rx timing error groups to LMF.

Proposal 3-3

* Support a TRP to provide the association information of RTOA measurements with Rx TEGs to LMF when the TRP reports the RTOA measurements to the LMF.
  + FFS: details of signalling and procedures
* FFS: Support a TRP to provide Rx timing errors per Rx TEG to LMF when the TRP reports the UL measurements to LMF.
* Note: If the association information is not provided, it is assumed RTOA measurements have the same Rx timing errors.

Comments

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| **Company** | **Comments** |
| MTK | 1, we don’t think there is a need to provide RX TEG to LMF |
| vivo | Same views as proposal 3-2a and 3-2b. |
| Huawei/HiSilicon | We do not think the TEG concept has any relevance to the gNB. |
| CMCC | Refer to our comments on Proposal 3-2a |
| CATT | Support. |
| Qualcomm | Support. Same reply above regarding the procedural. Timing errors exist in both Ues and gNB; discussion should progress in similar pace for both types of devices. |
| Nokia/NSB | If the TRP can know the RX error then it can correct the measurement itself. If the TRP can’t know the RX error then we could discuss other solutions. |
| Ericsson | Ok. But the FFS is not needed as we do not see the need for a TRP to provide Rx timing errors to the LMF. |
| Apple | Similar views as 3-2a |
| China Telecom | Similar comment as Proposal 3-2a. |
| ZTE | Same views as proposal 3-2a and 3-2b. |
| LG | Simialr view as 3-2a. |
| FL | Proposal 3-3 is about the TRP Rx timing errors, which are not related to TRP time synchronization errors. Suggest further discussion on the proposal if we can agree to introduce the TRP Rx REGs. |
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Proposal 3-3 (Revision 1)

Consider 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 UL Tx timing errors per Tx TEG to LMF for UL TDOA positioning.
* Option 4:
  + Support a UE to provide UL Tx timing error differences between Tx TEGs to LMF for UL TDOA positioning.
* FFS: details of signalling and procedures, UE capability
* **Note**: Depending on the discussion results, none/one/multiple of above options may be adopted in Rel-17.

Comments

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| **Company** | **Comments** |
| vivo | Same view as proposal 3-2, We can’t agree with this description like “ Rx TEG of TRP”. |
| Huawei/HiSilicon | Currently we do not have preference over TEG at TRP side, as we do not think a single TRP is likely to have multiple TEGs for indoor environment, and even if so, we can split the TRP into multiple TRPs, but we are fine to currently include the options. |
| CATT | Support. We prefer Option 2. Tx TEG in UE should be reported to LMF, since Tx TEG in UE is more important and Rx timing delay error may be compensated in TRP side. |
| Qualcomm | I think the following options of UE reporting “TxTEG timing differences” to the LMF is missing. |
| Nokia/NSB | Generally okay for us to list options like this and agree with QC comment. |
| FL | For vivo and HW’s comments, I understand companies have different views on the options. Here, we are trying first to lay out the options that we may consider. Option 1 also depends on the discussion on Proposal 3-1. Obviously, if the introduction of “TEG of TRP” cannot be agreed, Option 1 is no longer needed.  For QC’s comments, I added the UE reports “TxTEG timing errors” and “TxTEG timing error differences” as Option 3 and Option 4, which may be subject to UE’s capability. |
| Apple | Same view as 3-2 |
| Ericsson | We support Option 2. Also fine with Option 1 if TEG for TRP can be agreed.  As we do not see the need for TRP or UE to report their timing errors to the LMF, we do not support Options 3 and 4. |
| OPPO | Regarding Option.3/4, one question for clarification. If UE can know the Tx timing error, why does UE not compensate it? |
| CMCC | Basically support, similar comments as for Proposal 3-2 |
| China Telecom | we support the option 2 and also fine with Option 1. For the other options, we have the same view as 3-2. |
| CATT-2 | For the updated FL’s proposal 3-3(Revision 1) [in which Option 3 and Option 4 are added], we prefer to support Option 2+3+4. Tx TEG in UE side should be reported to LMF, since Tx TEG in UE side may be associated with different RF chains. Moreover, Rx timing delay error may be compensated in TRP side. |
| ZTE | Support option 2. |
| LG | Suppor the FL’s proposal |

Proposal 3-3 (Revision 2)

Consider 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 UL Tx timing errors per Tx TEG to LMF for UL TDOA positioning.
* Option 4:
  + Support a UE to provide UL Tx timing error differences between Tx TEGs to LMF for UL TDOA positioning.
* FFS: details of signalling and procedures, UE capability
* **Note**: Depending on the discussion results, none/one/multiple of above options may be adopted in Rel-17.

Comments

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| **Company** | **Comments** |
| Nokia/NSB | Same comment as on Proposal 3-2 (Revision 2). |
| CATT | Support. we prefer Option 2+3+4. Tx TEG in UE side should be reported to LMF, since Tx TEG in UE side may be associated with different RF chains. Moreover, Rx timing delay error may be compensated in TRP side. |
| Intel | If TRP Rx timing error is compensated on gNB side, we do not see the value of option 1. If compensation is not applied then we need to report TRP Rx timing errors, and following options need to be added:   * Option 5:   + Support a TRP to provide UL Rx timing errors per Rx TEG to LMF for UL TDOA positioning. * Option 6:   + Support a TRP to provide UL Rx timing error differences between Rx TEGs of two TRPs involved into UL TDOA measurement to LMF for UL TDOA positioning. |
| FL | For Intel’s comments:   * Option 1 is for the case that TRP does not know the Rx timing error, thus is unable to compensate; * For Option 5 proposed by Intel, if TRP already knows the Rx timing error, the TRP should compensate them. It is unclear why the option is needed; * For Option 6, it is unclear how a TRP knows the UL Rx timing error differences between Rx TEGs of two TRPs. |

Proposal 3-3 (Revision 3)

Consider 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 UL Tx timing errors per Tx TEG to LMF for UL TDOA positioning.
* Option 4:
  + Support a UE to provide UL Tx timing error differences between Tx TEGs to LMF for UL TDOA positioning.
* FFS: the details of the signalling, procedures, and UE capability
* 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.

Comments

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| **Company** | **Comments** |
| vivo | Generally support.  And we share similar views as proposal 3-2 that add an FFS for “TEG of TRP” in an explicit way. |
| ZTE | The same reason with the proposal 3-2, in addition of option 4, we would like to add another two options,   * Option 5:   + Support a UE to provide the information to LMF that indicates whether the Tx timing errors of SRS resources for positioning have been calibrated/pre-compensated locally within a certain margin. * Option 6:   + Support a TRP to provide the information to LMF that indicates whether the Rx timing errors of RTOA measurements have been calibrated locally within a certain margin. |
| Huawei/HiSilicon | We would suggest to add another Note: Other options are not precluded.  In particular, we assume that reporting SRS resource (set) ID associated with the measurement from TRP to the LMF may also be helpful. |
| CATT | Support. We think that these four options are potential technical solutions, which are worthy of further discussion. |
| FL | For vivo’s comments:   * It seems no need to add “FFS” to particular options, since all these options are listed for consideration.   For ZTE’s comments:   * I assume both UE and gNB are assumed to calibrate their Tx/Rx timing errors within a certain range to meet potential RAN4 performance requirements by default. Does ZTE propose different types of gNB to meet different performance requirements?   For HW’s comments:   * The suggested note seems applicable to Proposals 3-2/3-3/3-6. So, I added the notes to all three proposals. |
| Nokia/NSB | Okay. |
| ZTE | To FL. Please find our response on proposal 3-2. |
| Apple3 | Same comment as P3-1 Rev3, and similar to P3-2 Rev3. In addition, why UE TX TEG is needed, for RTOA it is cancelled, right? |
| FL | For ZTE’s comments, please see the response no proposal 3-3.  For Apple’s comments, the example that UE TX TEG may be benefit is when UE transmits SRS resources from different antenna panels. |
| LG | We are OK with FL’s proposal. |
| Ericsson | We support Option 2. Also fine with Option 1 if TEG for TRP can be agreed.  As we do not see the need for TRP or UE to report their timing errors to the LMF, we do not support Options 3 and 4. |
| ZTE | To FL. Same view as the proposal 3-2. |
| vivo 2 | Should we revise the proposal based on the update of 3-2? |
| Intel | Support in principle.  Support to study the list of considered options and perform down selection at the next meetings.  Suggest replacing the “TRP” with “TRP/gNB” in the text of the proposal. |
| FL | For ZTE’s comments:   * Proposal 3-3-1 is added to address ZTE’s comments   To vivo:   * Sure. If companies have the similar comments to Proposal 3-3 as to Propsal 3-2. Please indicate that. |

FL Comments

Proposal 3-3 (Revision 4) is basically the same as Proposal 3-3 (Revision 3) after accepting all of the changes of Proposal 3-3 (Revision 3) Please take a look to see if there is any additional comments.

### Proposal 3-3 (Revision 4)

Consider 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 UL Tx timing errors per Tx TEG to LMF for UL TDOA positioning.
* Option 4:
  + Support a UE to provide UL Tx timing error differences between Tx TEGs to LMF for UL TDOA positioning.
* FFS: the details of the signalling, procedures, and UE capability
* 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.

Comments

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| **Company** | **Comments** |
| Huawei/HiSilicon | Normally we do not think that it is necessary for the node report its internal TEG error (error difference) to another node. However, given that there are 4 options, we consider it beneficial for the discussion in the next meeting. |
| CATT | Support to keep all the Options. We can further discuss how to down-select in next meeting. |
| OPPO | For option 3 and 4: If UE knows Tx timing errors, why doesn’t UE compensate them? |
| Intel | Support in principle.  Support to study the list of considered options and perform down selection at the next meetings. |
| FL | For HW, OPPO’s comments:   * If a receiver (UE or TRP/gNB) knows its Rx timing errors, I would say it is reasonable to assume the receiver should compensate the Rx timing errors. For this meeting, it may be simpler to list the options. Similarly, if a transmitter (UE or TRP/gNB) knows its Tx timing errors, the transmitter should compensate the Tx timing errors. However, for this meeting, we don’t have the time to have a discussion on the options. It may be simpler to list the options. We could simply remove them once we reach a common undertsnading on whether the receiver is responsible for compensating the known Rx timing errors and the transmitter is responsible for compensating the Tx timing errors. |
| ZTE | Support in principle for further down selection. |
| Nokia/NSB | We agree with some of the above comments that if a node (UE or TRP) knows the timing errors then it should just compensate them. Since we have defined the errors as residual it doesn’t make much sense to us. That said if we change those options to “estimated” errors then we are okay to agree on optiosn for study. |

FL Comments

Proposal 3-3-1 is a new proposal based on the comments from ZTE to Proposal 3-3 (Revision 3) for further discussion. Please see the discussion of Proposal 3-3 (Revision 3) for the background of adding the proposal.

### Proposal 3-3-1 (new)

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

* Option 1:
  + Support a UE to provide the information to LMF that indicates whether the Tx timing errors of SRS resources for positioning have been calibrated/pre-compensated locally within a certain margin.
* Option 2:
  + Support a TRP to provide the information to LMF that indicates whether the Rx timing errors of RTOA measurements have been calibrated locally within a certain margin.
* FFS: details of signalling and procedures, UE capability
* 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.

Comments

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| **Company** | **Comments** |
| Huawei/HiSilicon | We do not think it is appropriate to discuss those options.  For example, Option 1 is like the UE capability issue. Option 2 is overlapped with Option 1 from Proposal 3-3. |
| vivo | It seems that we should add Option 3 here to align with ‘Option 3’ in Proposal 3-2-1.   * Option 3:   + Support LMF to indicate UE/gNB to use one Tx/Rx TEG for transmission/ reception   In addition, if both Proposal 3-2-1 and Proposal 3-3-1 are agreed, similar proposals should be added to section 3.6 for mitigating Tx/Rx timing errors for multi-RTT positioning. |
| LG | We are not supportive with this new proposal. We have similar comment on this proposal. For option 1, UE does not need to report whether the TX timing erros have been calibrated for “each SRS resources”. if the UE has the calibration capability. |
| CATT | We prefer to let proposal 3-3-1 (New) as low priority in this meeting. |
| OPPO | Not support any option. Similar comments as for Proposal 3-2-1(New) |
| Intel | Support in principle. |
| ZTE | Support the proposal.  To Huawei/LG/OPPO, please find our responses in Proposal 3-2-1(New). |
|  |  |

## Mitigating UE Tx timing errors for UL RTOA

FL comments

UL measurement accuracy (e.g., RTOA) may be impacted by UE Tx timing errors. When a TRP measures the UL SRS and reports the RTOA measurements, the TRP may not have the information of the UE Tx timing errors, and thus may not be able to mitigate the UE Tx timing errors when reporting the RTOA measurements. Some companies propose (e.g., [4][5][13][15]) to support UE to provide the UE Tx timing errors to LMF if the UE can support it. UE Tx timing errors may be different for different antennal panels/RF trains. There can be multiple Tx timing error groups for a UE, and each TEG may be associated with one or more UL SRS resources.

Proposal 3-4 (closed, merged with Proposal 3-2)

* A UE should support providing the association information of UL Tx TEGs with the SRS for positioning resources to LMF
* Depending on UE’s capability, a UE may provide the UL Tx timing errors per Tx TEG
  + FFS: UE may provide the difference of the Tx timing errors between a TEG and a reference TEG to LMF.
* FFS: details of signalling and procedures

Comments

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| **Company** | **Comments** |
| vivo | It seems too early to answer whether to support this proposal, considering that we are not yet sure how to estimate or mitigate the Rx/Tx timing error in UE’s Tx TEG.  And we should notice that SRS transmission associated with ‘panel ID’ has already been discussed in R17 MIMO enhancements. If this issue is discussed separately in positioning WI, it is very likely that two different ways (or parameters) will appear in the RRC ignalling to indicate the same relationship (SRS transmission associated with ‘panel ID’), which will increase the configuration overhead and cause duplicated work.  Do we need to clarify the difference with MIMO study? |
| Huawei/HiSilicon | OK with the first bullet.  For the second bullet, our question is why we need UE to report instead of UE to pre-compensate the “known” or “estimated” Tx timing error. |
| CMCC | Generally fine with the first bullet. |
| CATT | Support. |
| InterDigital | Support. UL Tx timing erros can be used by LMF to correct timing related measurements observed from SRS for positioning |
| Qualcomm | Support.  To Huawei: Lets take the example of MRTT:. The definition of UE Rx-Tx says, the Timing should be the subframe closest to the DL PRS. Imagine that this is subrame 0. The UE reports Rx-Tx measurement associated with subframe 0. Then, the SRS appears in subframe 10. The UE gets a TA command, or does an autonomous TA correction in the time between subframe 0 and subframe 10; e.g. moves by 10 nsec later. Then, the SRS is 10 nsec later, and the gNB Rx-Tx is overestimated by 10 nsec. If the UE reports a Timing correcton to the LMF, the LMF would receive the gNB Rx-Tx, remive the 10 nsec, and then add it with the UE Rx-Tx, and get a correct RTT.  Furthermore, agreeing on UE TxTEG without agreeing on gNB TxTEG, would not be acceptable for us. The spec has DL methods, UL methods, and DL&UL methods. I don’t see why have reporting only from the UE side, when positioning methods are affected equally from errors from both Ues and gNBs. |
| Nokia/NSB | Can the proponents explain the reason that the UE needs to signal this information and not simply correct for it locally? |
| Ericsson | Ok with the first bullet.  We think this proposal should be discsussed together with Proposal 3-3. |
| Apple | We do not support this proposal. Again not clear how UE estimates its Tx timing errors and if estimated, for what positioning measuements those info will be useful and how (e.g. for UL-TDOA in theory UE’s Tx error should be cancelled) |
| Huawei/HiSilicon | To QC:  I am not sure whether this is the correct question to discuss this example, but anyway, we think this is a generic issue when we consider TA. In the example, based on TS 38.215, it depends on whether the Tx timing of subframe #j that is closest in time to Rx timing of subframe #i is based on actually transmission or a virtual transmission, and if it is based on virtual transmission due to e.g. TDD configuration, whether UE should use actual SRS transmission subframe timing to recover the timing of subframe #j or use any other actual Tx transmission subframe timing to recover that of subframe #j. |
| China Telecom | Agree with Huawei/Hisilicon. |
| ZTE | We are fine with the first bullet. A more reasonable way could be that, UE is restricted to transmit SRS with the same UE Tx TEG by implementation, because some UEs have only one RF chain to transmit. Suggest to remove the second bullet, the UE capability should be discussed in proposal 3-7.Additionally, SRS could be MIMO SRS. |
| LG | Support. We have similar view with QC. |
| FL | Based on the comments, most companies do not think it is necessary to have the 2nd bullet, but support to have the 1st bullet. We may further dicuss the 1st bullet if we can reach the consensus on the UE Tx TEG as shown in Proposal 3-1. |
|  |  |

FL comments

The discussion is merged to Section 3.2

## Mitigating UE Rx timing errors for RSTD

FL comments

UE Rx timing errors will impact the RSTD measurement accuracy. If the Rx timing errors are known to the UE, the UE may remove the impact of Rx timing errors before reporting RSTD measurements(e.g. [14]). In this case, there is no need for a UE to report Rx timing errors. However, the UE may not always have the information of the Rx timing errors. In this case, it would be helpful for the LMF to know the association of the UL measurements with the Rx TEGs.

If UE uses different antenna panels/Rx chains for the receptions of the same or different DL PRS resources. The RSTD measurements may be impacted by different Rx timing errors. There are different proposals on how to deal with the different Rx timing errors. One of the proposals is to provide the association information of RSTD measurements with the Rx TEGs to LMF when the UE reports the UL measurements to the LMF, the LMF will take the information into account. Another possible solution is the UE performs self-estimation/calibration of the offset of Rx timing errors between Rx time error groups, e.g., by tracking the Rx time difference from the antenna panels/Rx RF chains from the same DL RS, i.e., SSB from the serving cell. If self-calibration of Rx timing errors between Rx TEGs are supported by UEs, it may make the solutions of the Rx timing errors much simpler. Also, there is a need to further discussion on how to deal with the impact of the Rx timing errors when a UE uses different antenna panels/RF chains for the receptions of the same or different DL PRS resources if UE cannot support the self-calibration.

Proposal 3-5 (closed, merged with Proposal 3-3)

* A UE should support providing the association information of RSTD measurements with different Rx timing errors to the different Rx TEGs to LMF when the UE reports the UL measurements to LMF.
* FFS: Depending UE’s capability, a UE may support providing Rx timing errors per Rx TEG to LMF.
* FFS: details of signalling and procedures

Comments

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| **Company** | **Comments** |
| MTK | 1, we don't see RX TEG reporting is needed |
| vivo | Same views as proposal 3-4 |
| Huawei/HiSilicon | OK with the first bullet.  For the second bullet, our question is why we need UE to report instead of UE to pre-compensate the “known” or “estimated” Rx timing error. |
| CMCC | Generally fine with the first bullet. |
| CATT | Support. |
| Qualcomm | Support  To MTK: The UE may be measuring RSTDs on PRS resources that are far away in time. The UE may know that there may be some time drift, so it may choose to say that these RSTD are part of a different RxTEG to suggest to the LMF that maybe these measurements should not be subtrached out. The UE may not know houw much is the time drift. If the UE knows, and can remove it from the report, that’s great; the UE will just say that these 2 RSTDs are in the same RxTEG.  Furthermore, agreeing on UE RxTEG without agreeing on gNB RxTEG, would not be acceptable for us. Progress should be symmetric. |
| Nokia/NSB | If the intention is to allow the LMF to know which measurements can be combined for differential purpose then we are open to discuss. If that is not the intention can the proponents explain further? |
| Ericsson | Ok in principle. We do not think the FFS is needed as we do not see a need for UE to provide the Rx timing errors to the LMF. It is enough to send an idenfier of the Rx TEG. But we suggest the following revisions:   * A UE should support providing the association information of Rx TEG identifier as part of RSTD measurements to LMF when the UE reports the DL measurements to LMF. * FFS: details of signalling and procedures |
| Apple | Similar comment to as proposal 3-4 |
| China Telecom | Support the first bullet. |
| ZTE | Same view as comments in proposal 3-4. Additionally, UE may indicate in measurement report whether the same RF chain is used for different PRS receptions. |
| LG | We are OK with the first bullet. |
| MTK | For the first bullet: A UE should support providing the association information of RSTD measurements with different Rx timing errors to the different Rx TEGs to LMF when the UE reports the **UL** measurements to LMF. 🡨 this is typo? Why UE reports UL measurement?  We gave detailed description on Proposal 3-1. For the example QC mentioned above, the below is our opinion,  2, If the two TOA measurements are conducted at different time and by the same RF chain and same frequency layer, then RX side timing delay may not be cancelled perfectly for this RSTD measurement. We need to understand whether this is useful case, because DL-PRS is comb structure, which allows multiple TRPs to transmit at the same time. So UE can form the RSTD measurement based on the TRPs transmitting at the same time (same slot, different comb index). If UE reports this RSTD value to location server and notify that, the two TOA measurements are performed at different time instance, what the location server can do? Drop it? If location server would drop it, why UE sends such reporting? It waste uplink resource  3, If the two TOA measurements are conducted at the same time and by different RF chain, for example, different panels and same frequency layer, then RX side timing delay may not be cancelled perfectly for this RSTD measurement. For this case, UE may support simultaneous reception from two panels (with different QCL type-D), and this should be UE capability. Also, if UE reports this RSTD to location server, and also reports that the RSTD is derived by different TEG, then what the location server can do? The root cause should be, UE should avoid using different panels to receive for getting RSTD under higher accuracy requirement |
| FL | Based on the comments, many companies do not think it is necessary to have the 2nd bullet, but supportive to have the 1st bullet. The proposal is revised to include only the 1st bullet. |

FL comments

The discussion is merged to Section 3.3.

## Mitigating Tx/Rx timing errors for multi-RTT positioning

FL comments

For multi-RTT positioning, the round-trip-time is calculated by the use of the UE Rx-Tx time difference measurements and gNB Rx-Tx time difference measurements. The measurement accuracy of UE Rx-Tx time difference measurements may be impacted by UE Rx and Tx timing errors, and the measurement accuracy of gNB Rx-Tx time difference measurements may be impacted by both gNB Rx and Tx timing errors. If UE Tx and Rx timing errors and gNB Tx and Rx timing errors cannot be compensated, the accuracy of the multi-RTT positioning may be significantly impacted.

For mitigating UE RX/TX timing errors, one proposed solution is that UE is responsible for the compensation of the UE Tx/Rx timing errors in UE Rx-Tx time difference measurements by the implementation (e.g., [1][8]).

For mitigating gNB RX/TX timing errors, one proposed solution is that gNB is responsible for the compensation of the TRP Tx/Rx timing errors in gNB Rx-Tx time difference measurements by the implementation (e.g., [1]), while another proposed solution is that the gNB reports TRP ‘Rx timing error + Tx timing error’ to LMF, and then let LMF mitigate the impact of TRP ‘Rx+Tx timing errors’ on gNB Rx-Tx time difference measurements (e.g., [8]).

Another proposed solution to handle the UE/gNB Tx/Rx timing errors in Multi-RTT is that UE and gNB are responsible for the compensation of the UE/TRP Rx timing errors by the implementation, while LMF is responsible for the compensation of the UE/TRP Tx timing errors, which may be provided by UE/gNB or estimated by LMF, to the UE/gNB Rx-Tx time difference measurements (e.g., [14])

If the UE and/or gNB have the information of their Rx/Tx timing errors, it may be reasonable to assume UE/gNB will perform the self-calibration of these errors. That is, UE/gNB Rx-Tx time difference measurements only contain the UE/gNB Rx/Tx timing errors that are unknown to UE/gNB, and cannot removed by self-calibration. In this case, to support LMF to mitigating UE/gNB Rx/Tx timing errors from the UE/gNB Rx-Tx time difference measurements (e.g., through the combination of the measurements), a different proposal is that UE and gNB provide the information of Tx/Rx REGs along with the UE/gNB Rx-Tx time difference measurements in the measurement report to LMF, and LMF will take the information into account during the positioning calculation to minimize the impact of the errors (e.g., [2],[17][19]).

Proposal 3-6a (Revised)

* UE should support providing to LMF the association information of UE Rx-Tx time difference measurements with the different UE Rx TEGs if UE Rx-Tx time difference measurements in a measurement report have different Rx timing errors;
* UE should support providing to LMF the association information of UE Rx-Tx time difference measurements with the different UE Tx TEGs if UE Rx-Tx time difference measurements in a measurement report have different Tx timing errors;
  + Note: A UE Tx TEG may be associated with one or more SRS for positioning resources.
* FFS: details of signalling and procedures

Proposal 3-6b (Revised)

* Support TRP to provide to LMF the association information of gNB Rx-Tx time difference measurements with different TRP Rx TEGs if the gNB Rx-Tx time difference measurements in a measurement report have different Rx timing errors;
* Support TRP to provide to LMF the association information of gNB Rx-Tx time difference measurements with the different TRP Tx TEGs if the gNB Rx-Tx time difference measurements in a measurement report have different Tx timing errors;
  + Note: A TRP Tx TEG may be associated with one or more DL PRS resources.
* FFS: details of signalling and procedures

Comments

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| --- | --- |
| **Company** | **Comments** |
| MTK | 1, the RX timing error, even due to different panel, could be corrected before measurement reporting. So RX TEG reporting seems not critical |
| vivo | Same views as proposal 3-4 |
| Huawei/HiSilicon | Same comments as before.   * UE reporting “TEG” info should be OK. * UE reporting “TEG” error is not needed. * gNB reporting “TEG” info or error is not needed. |
| CMCC | See comments on 3.2 to 3.5. |
| CATT | Support. |
| Qualcomm | Support. Please see our replies before on the explanations. |
| Nokia/NSB | If the intention is to allow the LMF to know which measurements can be combined for differential purpose then we are open to discuss. If that is not the intention can the proponents explain further? |
| Ericsson | The UE can provide TEG idenfiers associated with a measurment. No need to reporting the timing errors to LMF.  Similarly, gNB can provide TEG idenfiers associated with a measurement. No need to report the timing errors to LMF.  Suggest to discuss 3.6a and 3-6b together. |
| Apple | As mentioned previously, the question to us is how the reporting entity determines the association between timing errors and the reception/transmission of RS for positioning is determined, and how estimates the errors. We are OK to further discuss. |
| ZTE | Same comments as proposal 3-1, 3-2a and 3-4. additionally, we suggest to discuss section 3.1-3.5 first, then we can see whether we need further change to facilitate MRTT method. |
| FL | It seems companies have different views on whether to UE/TRP needs to report the information related to Rx/Tx “TEG”. Maybe we can modify the proposal to list the options of the enhancements for further discussion. |

Proposal 3-6 (Revision 1, Revised)

Consider following options for mitigating UE/TRP Rx/Tx timing errors in Multi-RTT:

* Option 1:
  + Support UE to provide to LMF the association information of UE Rx-Tx time difference measurements with the UE Rx TEGs in the measurement report for multi-RTT positioning
* Option 2:
  + Support UE to provide the association information of UE Rx-Tx time difference measurements with UE Rx TEGs in the measurement report to LMF, and TRP to provide the association information of gNB Rx-Tx time difference measurements with TRP Rx TEGs in a measurement report to LMF for multi-RTT positioning
* Option 3:
  + Support UE to provide to LMF the association information of UE Rx-Tx time difference measurements with the UE RxTx TEGs in the measurement report for multi-RTT positioning
  + Support UE to provide the association information of UE Rx-Tx time difference measurements with UE Rx TEGs in the measurement report to LMF, and TRP to provide the association information of gNB Rx-Tx time difference measurements with TRP Rx TEGs in a measurement report to LMF for multi-RTT positioning
* FFS: details of signalling and procedures
* **Note**: Depending on the discussion results, none/one/multiple of above options may be adopted in Rel-17.

Comments

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| **Company** | **Comments** |
| vivo | Same view as proposal 3-2, We can’t agree with using this description like “ Rx TEG of TRP” in option. We agree with the FL’s online proposal, we can focus on one panel first especially for TRP. |
| Huawei/HiSilicon | Currently we do not have preference over TEG at TRP side, as we do think a single TRP is not likely to have multiple TEGs for indoor environment, and even if so, we can split the TRP into multiple TRPs, but we are fine to currently include the options. |
| CATT | Support. We think the TRP Rx TEGs or UE Rx TEGs can be reported to LMF together with gNB Rx-Tx time difference or UE Rx-Tx time difference. And it is FFS whether TRP Tx TEG or UE Tx TEGs also need to be reported to LMF. |
| Qualcomm | To FL: For RTT what matters is the Rx-Tx TEG. If the UE just reports the RxTEG associated to an Rx-Tx, it can be the timing that is different. Is the assumption that the UE reports the TxTEG also?  I think it is simpler in M-RTT to define just a single RxTxTEG, since either way it is a separate measurement report compared to TDOA. We would like this option to be included also for discussion. |
| Nokia/NSB | Okay with listing options as done by FL. |
| FL | To QC’s comments, yes, for Multi-RTT what matters is the Rx+Tx timing error. Thus, it can also be an option to have {Tx TEG+Rx TEG}.  UE/TRP Rx/Tx timing errors may be impacted by {UE Tx timing error, UE Rx timing error, TRP Tx timing error, TRP Rx timing error}, or { UE Tx timing error+UE Rx timing error} and { TRP Tx timing error+TRP Rx timing error}. It seems we have much more options for Proposal 3-6.  For example, in UE side, we have:   * 1. UE is responsible for precise calibration of UE Rx/Tx timing errors (No enhancement is needed);   2. UE is responsible for precise calibration of UE Rx timing errors only      1. We only need to consider UE Tx TEG;   3. UE is responsible for precise calibration of UE Tx timing errors only      1. We only need to consider UE Rx TEG;   4. UE may not be able to calibrate UE Rx and Tx timing errors;      1. We may consider UE Tx TEG and Rx TEG separately, or      2. We may consider UE (Rx+Tx) timing errors, e.g., RxTxTEG, as QC’s suggested, although it may have following potential issues:         1. a) The number of RxTxTEGs (N\*M) may be much larger than consider Tx TEGs and Rx TEG separately; and         2. b) it may also make it more difficult for LMF to estimate/mitigate the Rx and Tx timing errors. Because the number of unknowns will be N\*M, instead of (N+M), if we assume there are N Tx TEGs and M Rx TEGs.   I modified the Proposal 3-6 to Revision 2) for further comments. |
| Ericsson | Please see our comments in Revision 2. |
|  |  |

Proposal 3-6a (Revision 2)

Consider 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.
* FFS: the details of signalling, procedures and UE capability
* 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.

Proposal 3-6b (Revision 2)

Consider 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
    - FFS: the definition of TRP RxTxTEG. It includes both TRP Rx timing and TRP timing errors.
* FFS: the details of signalling and procedures
* 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.

Comments

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| **Company** | **Comments** |
| CATT | Support both proposals. We prefer Option 4 in both proposals. We think both the Rx TEGs and Tx TEGs should be reported to LMF together with gNB Rx-Tx time difference or UE Rx-Tx time difference. |
| Ericsson | We think Option 3 is enough in both proposals. Not sure if we should define TRP RxTxTEG and UE RxTxTEG in addition to the TEGs we defined in Proposal 3-1 (Revision 1). |
| OPPO | From our understanding,   * if the measurements with different Rx TEGs, they should be associated with different RxTx TEGs no matter they are associated to the same or different Tx TEGs * if the measurements with different Tx TEGs, they should be associated with different RxTx TEGs no matter they are associated to the same or different Rx TEGs   Thus, there seems no need to introduce the concept of RxTx TEGs |
| CMCC | Not sure what is meant by RxTx TEGs, for us, option 3 for Proposal 3-6a/b seems OK. |
| ZTE | Support Proposal 3-6a. |
| Nokia/NSB | Same comment as on Proposal 3-2 (revision 2). |
| Qualcomm | To OPPO, Ericsson, CMCC: We have a different understanding than OPPO. The UE may derive 2 RxTx measurements, wherein the Rx timing is different, but still the UE ensures that the Rx-Tx timing error is the same (within a margin) by controlling the Tx timing accordingly. Imagine an example of a UE receiving PRS and transmit SRS from 1 panel, and receiving PRS and transmit SRS for a 2nd panel, such that, even if the Rx/Tx timings for each panel are different, the UE ensures that the Rx-Tx is the same.  In other words, if 2 Rx-Tx measurements belong in both different Rx groups and Tx groups, then it doesn’t mean that their Rx-Tx errors are different, or stated differently, that they belong in different RxTx groups. 2 Rx-Tx measurements can belong in the same RxTxTEG but different Rx-TEG and Tx-TEG. Either way however, for RTT, there is no need to know which Rx-TEG or Tx-TEG a measurement is.  Fast forward on what Ran4 may eventually do, if such groups are specified, the measurement requirements would be different for Rx-Tx and RSTD; For RTT, the calibration of Rx-Tx is really what matters, and not whether the Rx timings are calibrated and the Tx timings are calibrated. Having the right framework and measurement specific requirements and reporting would enable simpler specification and misunderstanding across groups. Example of a potential misunderstanding: If we only define Rx-TEG and Tx-TEG with an X nsec margin, how would that translate to a UE Rx-Tx calibration requirement, or how well should an LMF expect 2 Rx-Tx measurements are close? Are the Timing errors in Rx and Tx independent random variables with a well-known distribution, so taking the difference between the 2 random variables would be well defined? They are not.  Furthermore, in RTT, the devices reports Rx-Tx measurements in a separate reporting measurement, what the LMF needs to know is whether 2 Rx-Tx measurements have the same error, not whether their respective Rx or Tx timing have the same error. In RTT, there is no usefulness in just an one-way timings.  The way I see it:   * For DL-TDOA, we care about Tx-gNB-TEG and Rx-UE-TEG * For UL-TDOA, we care about Rx-gNB-TEG and Tx-UE-TEG * For RTT, we care about RxTx-gNB-TEG and RxTx-UE-TEG   There can be a very simple way specifying this: Just add a Group-ID for each reported measurement in each measurement report (UE or gNB). Strictly speaking, we may not even have to talk about whether it is Rx/Tx or RxTX TEG, it is understood by the context. If we are within an RSTD report, the UE adds Rx-UE-TEGs, if we are in a Rx-Tx report, the UE adds a RxTx-TEG, etc.  Hope the above explanation clarifies it. |
| MTK | We think the RXTX TEG is applicable to DL+UL positioning methods. It means it is applicable for multiple-RTT, and also for DL-TDOA+UL-TDOA  In our analysis, assume UE TX and RX from panel A (we can also assume TX and RX from different panel )  under **baseband** point of view, the measured UE RX-TX time difference =ΔtTX\_tp1 + tof1 – mu + ΔtRX\_ue\_panelA + TA - symbol time (1)  under **antenna** point of view, the theoretical UE RX-TX time difference =ΔtTX\_tp1 + tof1 – mu - ΔtTX\_ue\_panelA + TA - symbol time (2)  This means, the difference between antenna view and baseband view is ΔtTX\_ue\_panelA +ΔtRX\_ue\_panelA . So if UE can estimate the round trip timing delay, UE can compensate it before reporting the UE RX-TX time difference as shown in equation (2)  If UE can estimate the round trip timing delayΔtTX\_ue\_panelA +ΔtRX\_ue\_panelA , UE can compensate it before reporting the UE RX-TX time difference.  Also,  under **baseband** point of view, the measured gNB RX-TX time difference = mu – TA +ΔtTX\_ue\_panelA + tof1 + ΔtRX\_tp1  - symbol time (3)  under **antenna** point of view, the theoretical gNB RX-TX time difference = mu – TA +ΔtTX\_ue\_panelA + tof1 - ΔtTX\_tp1 - symbol time (4)  This means, the difference between antenna view and baseband view is ΔtTX\_tp1 +ΔtRX\_tp1  . If gNB (tp1 in this example) can estimate the round trip timing delayΔtTX\_tp1 +ΔtRX\_tp1 , gNB can compensate it before reporting the gNB RX-TX time difference.  To sum equation (2) and (4), the desired time of flight ( tof1 ) can be derived since other terms are cancelled. Note that in equation (2) and (4), the timing delay terms are TX timing delay at TRP and at UE of a panel.  However, if UE use another round trip timing delay to compensate, say ΔtTX\_ue\_panelB +ΔtRX\_ue\_panelB , and  ΔtTX\_ue\_panelA +ΔtRX\_ue\_panelA =ΔtTX\_ue\_panelB +ΔtRX\_ue\_panelB  ,  and ΔtTX\_ue\_panelA != ΔtTX\_ue\_panelB  , ΔtRX\_ue\_panelA != ΔtRX\_ue\_panelB ,  then, UE will reportΔtTX\_tp1 + tof1 – mu - ΔtTX\_ue\_panelB - ΔtRX\_ue\_panelB +ΔtRX\_ue\_panelA + TA - symbol time (5)  The sum of equation (5) and (4) can still cancel round trip timing delay of UE. This means it is related to RXTX, not respective RX and TX  TOA1 = tof1 + ΔtTX\_tp1  + ΔtRX\_ue\_panelA  TOA2 = tof2 + ΔtTX\_tp2  + ΔtRX\_ue\_panelB  UE can compensate TOA1 and TOA2 such that  TOA1’ = tof1 + ΔtTX\_tp1  + ΔtRX\_ue\_panelA – (ΔtRX\_ue\_panelA +ΔtTX\_ue\_panelA )  TOA2’ = tof2 + ΔtTX\_tp2  + ΔtRX\_ue\_panelB  - (ΔtRX\_ue\_panelB +ΔtTX\_ue\_panelB )  Then the reported DL-RSTD becomes  DL-RSTD = TOA1’ – TOA2’ = tof1 – tof2 + ΔtTX\_tp1 - ΔtTX\_tp2 - ΔtTX\_ue\_panelA +ΔtTX\_ue\_panelB  (6)  Similarly for uplink measurement,  UL-RTOA by TP1= tof1 + ΔtTX\_ue\_panelA + ΔtRX\_tp1 -  UL-RTOA by TP2 = tof2 + ΔtTX\_ue\_panelB + ΔtRX\_tp2 -  TP1 can compensate UL-RTOA before reporting  UL-RTOA1’ = tof1 + ΔtTX\_ue\_panelA + ΔtRX\_tp1 - – (ΔtTX\_tp1 +ΔtRX\_tp1 )  And TP2 can compensate UL-RTOA before reporting  UL-RTOA2’ = tof2 + ΔtTX\_ue\_panelB + ΔtRX\_tp2 - – (ΔtTX\_tp2 +ΔtRX\_tp2 )  In location server, UL-RSTD = UL-RTOA1’ – UL-RTOA2’ = tof1 – tof2 – ΔtTX\_tp1 + ΔtTX\_tp2 + ΔtTX\_ue\_panelA -ΔtTX\_ue\_panelB (7)  As (6)+(7) , the timing delays are cancelled to leave tof1 – tof2  Similarly if the compensated DL-RSTD is to use the following relationship  ΔtTX\_ue\_panelA +ΔtRX\_ue\_panelA =ΔtTX\_ue\_panelC +ΔtRX\_ue\_panelC  ,  and ΔtTX\_ue\_panelA != ΔtTX\_ue\_panelC  , ΔtRX\_ue\_panelA != ΔtRX\_ue\_panelC  ΔtTX\_ue\_panelB +ΔtRX\_ue\_panelB =ΔtTX\_ue\_panelD +ΔtRX\_ue\_panelD  ,  and ΔtTX\_ue\_panelB != ΔtTX\_ue\_panelD  , ΔtRX\_ue\_panelB != ΔtRX\_ue\_panelD  Equation (6) can be re-written as  DL-RSTD = TOA1’ – TOA2’ = tof1 – tof2 + ΔtTX\_tp1 - ΔtTX\_tp2 + ΔtRX\_ue\_panelA -ΔtRX\_ue\_panelB  - (ΔtTX\_ue\_panelC +ΔtRX\_ue\_panelC) + (ΔtTX\_ue\_panelD +ΔtRX\_ue\_panelD ) (8)  Then as (7)+(8), the timing delays are cancelled to leave tof1- tof2. This means it is related to RXTX, not respective RX and TX  We think, the round trip timing delay (DAC to antenna and back to ADC) could be more feasible to calibrate, than the one-way timing delay  We further suggest to modify the title of 3.6 as Mitigating Tx/Rx timing errors for DL+UL positioning |
| OPPO | Thank Alexi for the detailed explanation. We understand QC’s intension. Based on our understanding, for the UE with 2 panel, we cannot assume the two panels belong to the same RxTxTEG. The reason are as follows  1. The Rx RF chain and Tx chain are corresponding to different paths.  There is also some switch(s) that may lead to different timing delays for Rx and Tx paths.  Proposal 3-6 only lists the potential options for further study. In the following meetings, RAN1 is expected to have more detailed investigation on these options. In order to facilitate the future RAN1 discussions, we suggest to send an LS to RAN4 and consult them on this issue. |
| ZTE | Similar comment as proposal 3-2. We would like to have another option for both proposal 3-6a and proposal 3-6b.   * Option 5 for proposal 3-6a :   + Support a UE to provide the information to LMF that indicates whether the Rx/Tx timing errors have been calibrated/pre-compensated locally within a certain margin. * Option 6 for proposal 3-6b :   + Support a TRP to provide the information to LMF that indicates whether the Tx/Rx timing errors have been calibrated/pre-compensated locally within a certain margin. |
| Huawei/HiSilicon | We still have difficulty understanding the motivation of RxTx TEG.  In QC’s example, the following RxTx TEG is possible where RxTEG1+TxTEG1 and RxTEG2+TxTEG2 belong to the same “RxTxTEG”, i.e. RxTxTEG1   |  |  |  | | --- | --- | --- | |  | TxTEG1 | TxTEG2 | | RxTEG1 | RxTxTEG1 |  | | RxTEG2 |  | RxTxTEG1 |   In our understanding, if there is a method to ensure/test/calibrate RxTEG1+TxTEG1 and RxTEG2+TxTEG2 to be within the same RxTxTEG, wouldn’t it be even easier to ensure RxTEG1 and RxTEG2 are in the same RxTEG, and ensure TxTEG1 and TxTEG2 are in the same TxTEG?  Even if it is possible through some method, we consider it to be the corner case, where the majority case would be multiple pairs (RxTEG, TxTEG) fall into the same “RxTxTEG” is equivalent to those RxTEGs and TxTEGs in the multiple pairs are belonging to the same RxTEG and TxTEGs. |
| LG | Thanks QC and MTK for the detailed explanation, but we are not sure why the option 4 is necessary.  Our understanding for TEG discussion is that the discussion on whether or not to introduce the TEG is necessary since some or most devices may not have capability to calibrate Rx/TX timing errors. In QC's example, it was assumed that even if the UE uses difference reception panels (different RX TEGs), the UE can adjust transmission timing (Rx-Tx time difference) so that it has the same RxTxTEG. In our understanding, this means that the UE knows the Rx timing errors and Tx timing errors so it is able to adjust its own timing errors. In this case, our understanding is that the UE can report Rx-TX time difference measurements with Tx/RX timing error calibration. |
| Qualcomm | Consider a UE not supporting DL/UL TDOA, but only RTT. Why would the UE need to pass RxTEG conformance tests and TxTEG tests (if these are defined), when what it really needs is just to ensure the Rx-Tx to be the same.  To put it differently, we may not even need to say whether it is RxTx or Rx or TX TEG eventually in the spec: The UE/gNB reports a measurement, and adds an ID index with which the LMF determines that the measurements have the same error.   * Why do we need to add 2 indeces in RTT when one is enough? * The measurement reports for RTT, TDOA are different.   To HW: We don’t need to go into implementation details, but we don’t consider it a corner cases. A UE in MRTT would only have to satisfy requirements on Rx-Tx, and not requirements on how the Rx timings are. To reverse the question, what would LMF learn more if we add 2 indeces? Either way, the ONLY way it is useful is by saying: Any measurement associated with a tuple of (RxTEG, TxTEG) has the same Rx-Tx Error, aka same RxTxTEG. The LMF would miss that, it may be possible, that the following 2 measurements have the same error:   |  |  |  | | --- | --- | --- | |  | TxTEG1 | TxTEG2 | | RxTEG1 | RxTxTEG1 |  | | RxTEG2 |  | RxTxTEG1 |   Another argument? Why add 2 indeces in the report, when 1 index is enough? More overhead, without really being useful.  In summary, having 2 separate indices for MRTT serves a subset of the cases than a single index. Even if it is a corner case, having a solution that serves all cases should be preferred, especially if is coming with lower overhead, simpler understanding on what test-cases to be eventually defined, and what should the UE requirements be.  To LGE, knowledge of Rx-Tx being the same, does not mean Knowledge that Rx timings are the same & Tx timings are the same. E.g: UE has an internal high-precision clock that it uses to count the difference in timing between the reception and the transmission. The reception timing may be lower precision, and the transmission timing may be lower precision, but using the internal high-precision clock the time difference between the transmission and the reception being higher precision.  I want to thank MTK for their detailed analysis and we **totally** agree with this statement from MTK:   * **“We think, the round trip timing delay (DAC to antenna and back to ADC) could be more feasible to calibrate, than the one-way timing delay”**   I would also like to clarify that, if the UE does not support TDOA methods, it may NOT even need to calibrate the one-way timing delays (with any higher precision than what communication requirements are). However, a UE may put extra efforts (RF, hardware, testing) to ensure that the time difference between PRS reception and SRS transmission is calibrated. |
| Nokia/NSB\_2 | Okay. |
| Huawei/HiSilicon | To QC, why would a UE support multi-RTT, but does not support UL-only positioning, as in our view what UE needs to concern is the Tx of SRS? Whether UL-TDOA/UL-AoA is used is mainly based on network side.  I do not see the difference between reporting two indices (RxTEG and TxTEG) and reporting single index (RxTxTEG) when it comes to overhead, because the bit width of the single index would presumably be larger than each one of the two indices, and the number of codepoints of RxTxTEG defined in the specification, if any, should be the product of number of codepoints of RxTEG and TxTEG. |
| Qualcomm3 | It may not support any additional calibration requriemetns that may be needed to support the feature of UL TEG; UL-only positioning is even transparent I the spec; however this does not mean that all future UEs will support any additional requirements on TxTEG / RxTEG unless it is necessary. We don’t see the need of such requirements for a UE supporting MRTT. That UE may say I support the RxTxTEG (and any requirements this may entail) for MRTT, but I only support the Rel-16 UL Positionign capabilities, and not the Rel-17 TxTEG reporting/requirements (due to, as explained before, a UE, based on its discretionary product roadmap, constraints, etc, etc may only decide to calibrate the Rx-Tx feature targetter for a rel-17 MRTT deployment, while not supporting the TxTEG feature).  I am going to reverse the question: What are the benefits of supporting 2 indeces for MRTT Report when 1 index can do the job? What are the benefits of supporting the concept of indeces that do not provide direct connection to the MRTT measurement reporting, but rather use indeces that are related to other reports and measurements? If the UE report a measurement of a X type, it should include information about that type, not about another measurement type. Note that one of the reasons we have separate reports, capabilities, requirements, is to be able to adjust/optimize each one, and not just have a generic bucket of UL positioning. |
| Huawei/HiSilicon | To Qualcomm, I can see the rationale of additional capability part for Rel-17 TEG and its impact on claiming support of a Rel-17 positioning method, e.g. Rel-17 Multi-RTT, but whether this type of partial calibration, i.e. only calibrate Rx+Tx chain without calibrate Rx or Tx chain individually may require further discussion.  The SRS TEG information regarding SRS transmission may be part of TEG information report to LMF for “Rel-17 UL-TDOA”, which we do not think should be associated with any “measurement” from UE side. This is reason why we do not think TEG information should always be associated with a “measurement” is a valid point.  In addition, what is the benefit of reporting single index over two indices if the set from which the single index is selecting is the Cartesian product of the two sets from which the two indices are selecting, respectively? Changing argument using the “measurement” associated with the index, from my understanding, does not mean that the bitwidth of the single index would be smaller than two indices combining.  Regarding the comment from MTK:   * **“We think, the round trip timing delay (DAC to antenna and back to ADC) could be more feasible to calibrate, than the one-way timing delay”**   One questions for clarification is that when we say round trip time to calibrate, are we referring to obtaining the true round trip time delay, or obtaining the difference between the true round trip time delay of two {RxTEG, TxTEG} pairs without obtaining the true values, at least not the whole true value?  To our understanding, when we say the one-way time to calibrate, we are actually referring to obtaining the delay difference between two TxTEGs (or beween two RxTEGs), without knowing the true value of the one-way time delay, which does not seem less feasible. |
| Qualcomm | Both 3-6a and 3-6b say: “consider the following options”, so we are currently in the phase that we are writing down the options that have some technical merit and try to reach consensus on a first framework to be discussed further. Excluding from the beginning the discussion on RxTx TEGs, when technical reasoning has been presented, would not help with progress.  Just to make sure on a final point, regarding this comment: “only calibrate Rx+Tx chain without calibrate Rx or Tx chain individually may require further discussion.”   * I am not saying that Rx and Tx timings will not be calibrated at all, this would not make sense; already Rel-16 UEs have some level of calibration, and RAN4 requirements are being discussed currently to decide what to add, if any. I am saying, if rel-17 introduces new features, one that says: UE can report some TxTEG associated to SRS transmissions, and another feature that the UE can report some RxTEG associated to PRS reception/measurements, if a UE supports only MRTT Rel-17, and not the TxTEG and RxTEG features, these 2 capabilities may be asking “more” from the UE than what is really needed for the purpose of MRTT positioning. What the UE needs to ensure is that 2 or more Rx-Tx measurements are calibrated, and we do think that this is a separate exercise/feature, and needs to be treated separately, as we (correctly, in my opinion) did in rel-16 to treat methods separately, with separate capabilities, assistance data, measurement reports, etc. |
| LG | Thanks for the discussion. To Qualcomm, Regarding the comment that “knowledge of Rx-Tx being the same, does not mean Knowledge that Rx timings are the same & Tx timings are the same.”, we agree with this but our concern was different. Sorry for the repeated our comment but I tried to describe our question more clearly below.  Our understanding on the mentioned example is that the UE can still ensure the same Rx-TX timing errors even if the UE measures DL PRS with different RX panels (different RX TEG) by controlling the TX timing accordingly. I would like to mention the conditions under which such UE’s behaviour is possible. In order for the UE to control TX timing to adjust the Rx-Tx timing error (RxTx TEG) to the intended value so that the Rx-Tx is the same, the UE should know the timing error values between different panels which need to be adjusted and the UE should have a capability for calibration. This kind of UEs can report the calibrated measurement, so we are still questionable that why the UE needs to report additional information such as TEG. |
| China Telecom | Reference to the definition of RxTx TEG in proposal 3-1, we are fine with both the proposals in general. In our understanding, introducing the RxTx TEG is for mitigating the time errors for multi-RTT positioning. Even though the Rx/Tx TEG have been defined and can be reported to LMF, introducing the RxTx TEG can also be useful for further discussion and positioning enhancement. And there seems no companies have concerns about the proposals but the ‘TxRx TEG’ issue, we may just endorse the proposal here and FFS the ‘FFS’s to help the progress. |
| Ericsson | We think Option 3 is enough in both proposals. |
| MTK | To Huawei,  1, For on-the-fly self-calibration (assume calibrate = estimate), what we are thinking is to estimate the actual round trip timing delay. At least UE has chance to transmit a signal from baseband, and wait for the signal back and observe in baseband  2, During the circuit design phase, we can know the TX and RX group delay by simulation. The corresponding process parameter (for example TSMC 7nm process) and temperature can also be configured to analyse the group delay. We are not sure the proper solution to perform the on-the-fly estimation of the one-side TX or RX timing delay when the self-calibration is conducted. Unless we don't need to do it on-the-fly and the variation due to temperature is within a margin from the circuit simulation  3, **Even though UE has multiple panels, it doesn't mean the timing delay would be quite significant. It could be still within a margin. Then we tend to treat it as a single TEG.**  4, We actually favor the differential solution which can somehow avoid the need of TEG definition. For example DL-TDOA and UE receives the 2 TRPs signals by same panel, same time, and same frequency, then UE RX TEG is actually not needed  5, for M-RTT using UE RX-TX time difference and gNB RX-TX time difference measurement, we feel that RXTX TEG in both the UE and gNB side are needed. This is because for both UE RX-TX time difference and gNB RX-TX time difference in antenna as reference point, each term contains the TX timing delays from both UE and gNB side,  under **antenna** point of view, the theoretical UE RX-TX time difference =ΔtTX\_tp1 + tof1 – mu - ΔtTX\_ue\_panelA + TA - symbol time (2)  under **antenna** point of view, the theoretical gNB RX-TX time difference = mu – TA +ΔtTX\_ue\_panelA + tof1 - ΔtTX\_tp1 - symbol time (4)  As such the summation of UE RX-TX time difference and gNB RX-TX time difference can properly cancel the delay  To FL,  We suggest to discuss 3-6 in next meeting, and change the title as Mitigating Tx/Rx timing errors for DL+UL positioning |
| FL | Dear all:  Thanks for the good discussions.  I assume companies may have different opinions on which TEGs (Rx/Tx/RxTx) are needed for which entities (UE/TRP) and for which positioning techniques (DL TDOA/UL TDOA/Multi-RTT) and for which positioning solutions (UE-based/UE assisted). In this meeting, my undertsnading for this meeting is that we will simply list these potential options for consideration without making the judgement or decision on which of the options will or will not be adopted in Rel-17.  For MTK’s suggestion to discuss 3-6 in next meeting, I am hoping we can reach some consensus based on the current proposal Proposal 3-6 if it is possible in this meeting. Then, in the next meeting we can further discuss the potential benefits and potential issues for these options, instead of still discussing whether the options need to be considered. Again, I would like to point out that the proposal only lists the options for considerations. It does not say which options are better than the others.  About the change of the title as Mitigating Tx/Rx timing errors for DL+UL positioning, I assume it is a reasonable suggestion. |
| Intel | For both proposals 3-6a and 3-6b:  We do not see a need to provide Option 1 and Option 2 separately.  We suggest to combine Option 1 and 2 in one option and remove Option 3. |

FL Comments

Proposal 3-6a/6b (Revision 3) are the same Proposal 3-6a/6b (Revision 2) after accepting all of the changes. Please

### Proposal 3-6a (Revision 3)

Consider 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.
* FFS: the details of signalling, procedures and UE capability
* 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.

### Proposal 3-6b (Revision 3)

Consider 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
    - FFS: the definition of TRP RxTxTEG. It includes both TRP Rx timing and TRP timing errors.
* FFS: the details of signalling and procedures
* 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.

Comments

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei/HiSilicon | Although we consider further discussion on the necessity for introducing RxTx TEG is needed, we can accept both Proposal 3-6a and 3-6b considering there may or may not be some merit on potential UE calibration effort.  We are fine with replacing multi-RTT with generic DL+UL positioning. |
| vivo | We found there are two types of TEG information in proposal 3-2, one is the association information of TEG(eg. Option 1 in 3-2), another is timing error values of TEG(eg. Option 3 in 3-2). But proposal 3-6 has only one type of TEG information here, which is the association information of TEG. Should we align with other proposals? |
| MTK | For DL+UL positioning, gNBs (TRPs) transmit PRS, and UE transmits SRS. Whe UE receives PRS, UE can perform UE RX-TX time difference measurement, or DL-RSTD measurement. When gNBs receives SRS, gNB can perform gNB RX-TX time difference measurement or UL-RTOA measurement.  Basically the measurement types using differential approach can automatically cancel the unwanted timing delay. Thus. For DL-RSTD measurement, the impairment would be the differential of the TX timing delays of 2 gNBs. For UL-RTOA measurement, if the two gNBs receive SRS from a UE by same TX TEG for transmission, then the differential of 2 UL-RTOA measurements (conducted at location server) would be impacted by the differential of the RX timing delays of 2 gNBs. If gNB knows about the RXTX (round trip) timing delays, gNB can compensate the UL-RTOA measurement by subtracting the estimated round trip timing delay. As such, the reported UL-RTOA measurements would be influenced by gNB TX timing delay, not gNB RX timing delay. The summation of DL-RSTD and the differential of 2 modified UL-RTOA reports can as a result, cancel the gNB TX timing delay. To sum properly, the gNB RXTX TEG may needs to be indicated to the location server  Therefore, if the UL-RTOA measurements from 2 gNBs can be ensured due to the transmission of same TX TEG of UE, then only gNB RXTX TEG needs to be taken care. If UE transmission or receiving contains using different TEGs, then both gNB RXTX TEG and UE RXTX TEG need to be taken care.  Therefore, the situation of simultaneous configuration of DL-TDOA and UL-TDOA for DL+UL positioning would be different from DL-TDOA only, and UL-TDOA only Proposal 3-6a (Revision 3) Consider 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 * FFS: the details of signalling, procedures and UE capability * 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.  Proposal 3-6b (Revision 3) Consider 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     - FFS: the definition of TRP RxTxTEG. It includes both TRP Rx timing and TRP timing errors. * Option 5:   + Support TRP to provide the association information of UL-RTOA measurements with TRP RxTx TEGs in a measurement report to LMF for simultaneous DL-TDOA and UL-TDOA configuration for positioning * FFS: the details of signalling and procedures * 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. |
| CATT | Support both proposals. We prefer to keep all the reasonable Options for mitigating UE/gNB Rx/Tx timing errors in DL+UL positioning(including Multi-RTT method and DL-TDOA+UL-TDOA method), and further discuss how to down-select in next meeting. |
| Intel | For both proposals 3-6a and 3-6b:  We do not see a need to provide Option 1 and Option 2 separately.  We suggest to combine Option 1 and 2 in one option and remove Option 3. |
| ZTE | Support in principle for further down selection.  To FL, considering we already have new proposal 3-2-1 and 3-3-1, we suggest to have another mirror proposal as following.  Consider the following options for mitigating gNB Rx/Tx timing errors in DL+UL positioning:   * Option 1:   + Support a UE to provide the information to LMF that indicates whether the Rx/Tx timing errors for Rx-Tx timing difference measurements have been calibrated/pre-compensated locally within a certain margin. * Option 2 :   + Support a TRP to provide the information to LMF that indicates whether the Tx/Rx timing errors for Rx-Tx timing difference measurements have been calibrated/pre-compensated locally within a certain margin. * FFS: details of signalling and procedures, UE capability * 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. |
| Nokia/NSB | While we do not support all the other options for RSTD and UL RTOA we would like to ask for clarification why Rx-Tx time difference measurements have such a different set of options (e.g., why is providing the errors considered in other measurements but not these)? |

## Feasibility/Capability of the calibration of UE/gNB Tx/Rx timing errors

Submitted Proposals

* (ZTE [R1-2100293](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100293.doc)) Proposal 1:
  + Send a LS to RAN4 to check that if it’s feasible the Rx and Tx timing delays can be calibrated and compensated at both UE and TRP side.
* (Ericsson [R1-2101754](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101754.doc))Proposal 9
  + RAN1 should with help from RAN4 study the possibility to define two (or multiple) sets of requirements (based on UE-capabilities) for RSTD accuracy, UE RX-TX time difference accuracy and UE TX timing accuracy in order to accommodate for both general purpose eMBB UEs and for UEs requiring high (sub-meter) accuracy positioning in e.g. I-IoT scenarios.
* (Ericsson [R1-2101754](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101754.doc))Proposal 10
  + Send LS to RAN4, requesting RAN4 to investigate the possibility to define two (or multiple) sets of requirements (based on UE-capabilities) for RSTD accuracy, UE RX-TX time difference accuracy and UE TX timing accuracy in order to accommodate for both general purpose eMBB UEs and for UEs requiring high (sub-meter) accuracy positioning in e.g. I-IoT scenarios.

FL comments

It is expected that UE and gNB will conduct at least some kind of calibration of Rx and Tx timing errors for supporting the positioning measurements (RSTD, RTOA, UE/gNB time differences). RAN4 would be the working group to provide the information of the realistic accuracy of the self-calibration of Rx and Tx timing errors, e.g., whether it would be accurate enough to support the Rel-17 target positioning accuracy etc.

### Proposal 3-7

* + Send a LS to RAN4, requesting the following information
    - investigate whether the Rx and Tx timing delays can be calibrated and compensated at both UE and TRP side to support the Rel-17 target positioning accuracy requirements
    - investigate the possibility to define two (or multiple) sets of requirements (based on UE-capabilities) for RSTD accuracy, UE RX-TX time difference accuracy and UE TX timing accuracy in order to accommodate for both general purpose eMBB UEs and for UEs requiring high (sub-meter) accuracy positioning in e.g. I-IoT scenarios.

Comments

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| **Company** | **Comments** |
| MTK | We support, and we can further check : whether one-side delay (DAC to antenna, and antenna to ADC) can be separately calibrated? Or only the round trip delay (DAC to antenna and back to ADC) can be calibrated with reasonable complexity |
| vivo | Support.  If the Rx/Tx timing delays can be calibrated and compensated by the UE or the TRP, the UE or TRP can automatically eliminate the timing delay in the measurement before reporting, which minimizes the specification impact. We are worried that premature normative work will make our efforts in vain before we get a response from RAN4. |
| Huawei/HiSilicon | Not sure RAN4 can handle it. We understand that even in Rel-16 performance WI, RAN4 is still struggling with the residue calibration error. |
| CATT | Support. We believe that RAN4 should be involved when we discuss the feasibility of the schemes to mitigate the Rx/Tx timing delays. |
| Qualcomm | No need to send an LS yet. If RAN1 agrees on the signaling of Timing Groups, then RAN4 may need to work on putting requirements related to these. We believe it is early to send an LS now, when they are still discussing Rel-16 requirements. |
| Nokia/NSB | We think that RAN1 needs to first get a better understanding of what exactly is in scope of the Rx and Tx timing delays before we can involve RAN4. |
| Ericsson | We support the second subbullet. |
| Apple | Is the intention of the first bullet to say UE (and gNB) do calibration by itself? |
| Samsung | One clarification question, so the purpose of the LS is to ask RAN4 whether a UE/TRP could measure (then compsensate) and/or calibrate the time errors by themselves, or with the methods we are discussing now in RAN1? |
| ZTE | Support the FL’s proposal |
| LG | Even if we are not sure that RAN4 can work on this, if this LS is to check the feasibility whether the UE and/or TRP can compensate/calibrate ofor both Rx and Tx timing dealys, we are fine. |

# Additional proposals

## Measurement Enhancements

Submitted Proposals

* (LGE [R1-2100708](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100708.doc)) Proposal 1:
  + Support enhancements for introducing measurement acquisition rule on UE Rx-Tx time difference measurement and gNB Rx-Tx time difference measurement
    - E.g., the same time window for measurement averaging of UE Rx-Tx and gNB Rx-Tx
* (LGE [R1-2100708](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100708.doc)) Proposal 2:
  + Support enhancements for introducing measurement acquisition rule on RSTD measurement and UE/gNB Rx-Tx time difference
    - E.g., the same time window for measurement averaging of RSTD and UE/gNB Rx-Tx.
* (Qualcomm [R1-2101468](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101468.doc)) Proposal 5:
  + Support Tx Timing Adjustment information Reporting from UEs to the LMF for DL+UL or UL-only positioning.

FL Comments

In [10], it was observed that the measurement averaging windows are currently up to implementations for both of the UE and the gNB, which may result in inaccurate measurement (e.g., RTT) and thus makes it difficult to use the UE/gNB measurements to obtain the extract TRP timing errors, especially when the UEs are not stationary. It was suggested that both the UE and the gNB should follow an aligned rule to determine a measurement for reporting of the Rx-Tx time difference and RSTD.

In [17], the impact of Tx TA adjustment on UL and DL+UL positioning when the [averaged] measurements obtained from multiple SRS occasion was discussed, where it was proposed for UE to provide the timing adjustment information to LMF to resolve the issue.

We may need to consider some additional rule(s)/enhancements to avoid the potential issues associated with the measurements obtained from multiple DL PRS/UL SRS occasions. One possible solution is to allow the network to configure a time window for positioning, during the time window, the UE should not adjust UL Tx Timing; while the UE may be allowed to adjust and/or report the Tx Timing Adjustment information to the LMF or gNB. Suggest further discussion on whether there is a need to consider additional rules/enhancements on the measurements.

### Proposal 4-1

* + Support LMF to configure a time window for UE/gNB measurements (RSTD, RTOA, UE/gNB Rx-Tx time difference)
  + Adopt one of the following options:
    - Opt. 1: UE should not make UL Tx timing adjustment for the transmission of SRS for positioning during the time window
    - Opt. 2: UE should support reporting Tx timing adjustment information to LMF [or gNB] if the transmission time of SRS for positioning is changed during the time window

Comments

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| **Company** | **Comments** |
| vivo | Not sure the issue should be discussed under this AI. |
| Huawei/HiSilicon | We understand the UE Tx timing is also associated reference DL timing, which can also be varying.  For Opt.1, this is too restrictive from UE implementation, and may not be valid, as the DL timing can also be changing.  For Opt.2, as commented during the online session, if UE changes the Tx timing, the resultant Rx timing at gNB is also changed accordingly, and in addition, the TOA measurement by the gNB has already been done. We are not sure how this information at LMF can help mitigate the UE Tx timing error.  In our understanding, the best way to mitigate different average algorithm between TRPs and between UE and TRPs is to adopt the method in Proposal 2-1 and Proposal 2-2. |
| CATT | We slightly prefer Opt.2, but need more study on whether Opt.2 have the benefit to the mitigiation of UE Tx timing delay error. |
| Qualcomm | We prefer Option 2. |
| Nokia/NSB | We are a bit unclear how this can help with Tx/Rx timing errors? If the LMF has timestamps isn’t this already possible? |
| Ericsson | We slightly prefer Option 2. With Option 2, RAN4 needs to be involved to set requirements on the timing adjustment information. |
| Apple | In our understanding the reference time for timestamp associated with UE measurement report is UE’s DL refernence. So adjustment of TA should not make a problem if that understanding is correct. |
| Samsung | Whether this reported timing adjustment is useful or not is dependent on whether gNB can detect the timing adjustment; ideally, yes, if UE Tx timing has a delta\_t, then the gNB receiving time can reflect the delta\_t as well, then it will be eliminated by the difference. However, in reality, whether the gNB detection on the sequence has good enough preciseness or granularity to fully reflect this delta\_t, since a few ns will create larger distance gap. |
| OPPO | For the first bullet, we don’t see the necessity to introduce a time window.  For the second bullet, why is it needed to couple a window for measurement and the reporting of Tx timing adjustment? On the other hand, UE will adjust the timing according to NW’s timing advance command. Does Option.1 intend to not follow the TA command of NW? |
| ZTE | Low priority issue. We should discuss high priority issues first. |
| LG | We are fine either option 1 or option 2. |

## Antenna array phase center offset

Submitted Proposals

* (Nokia [R1-2100548](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100548.doc)) Proposal 1:
  + RAN1 to include UE antenna array phase center offset impact on UE positioning estimation accuracy and potential correction mechanisms in the work on UE and gNB Rx/Tx timing delay mitigation.
* (Fraunhofer [R1-2101131](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101131.doc)) Proposal 3:
  + The reference point for TRD determination is the phase center of the transmitted or received beam.

FL comments

It was observed in [7][13] that the antenna array phase center may not be a “static” point at the antenna connector or antenna center. 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. Suggest further discussion on how to consider the impact of the antenna array phase center offsets in addition to the introduction of the timing error groups.

### Proposal 4-2

* Further study the impact of UE antenna array phase center offset on UE positioning estimation accuracy and potential correction mechanisms

Comments

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| **Company** | **Comments** |
| vivo | We analyzed the contribution seriously containing UE antenna array phase center offset, but we still confused the impact on Rx/Tx timing delay. We hope we can get more explanation. |
| Huawei/HiSilicon | OK with the study. However, to our understanding, this requires understanding what the ground truth of UE location is, if we allow different UE antenna reference point defined. |
| CATT | It is not clear how much impact does this issue have on the positioning accuracy. We prefer this study as low priority in this meeting. |
| Qualcomm | Unclear what we need to study. |
| Nokia/NSB | Support the inclusion of phase center offsets in the Tx/Rx timing delays. As said online we see this as a very critical issue to solve if we truly want to achieve 20 cm level accuracy.  To CATT, as shown in our detailed simulation results the impact can be quite significant in a realistic UE. Almost 10 cm of error in some scenarios which is clearly significant for our targeted accuracies.  To vivo, thanks for analysing the issue. The figure from our Tdoc (shown here too for convience) is perhaps the best way to explain the impact on Rx/Tx timing delay. The antenna phase center effectively moves based on the AoD/AoA of the signals to/from the UE. This moves the PCO from the ARP shown in the figure (i.e., the location we want to find) and the red dot. It moves it by there being an effective additional delay (i.e., the ToA/ToD error shown here). |
| Ericsson | The impact of this issue on positioning accuracy is much smaller when compared to that of group delays. Low priority. |
| Fraunhofer | Support also suggest adding TRP to the proposal. Taking timing delay of a TRP is the signal propogation time between the antenna phase center and BB unit, the Tx/Rx delay if grouped according to the Rx antenna position (and not per beam center) the timing error between these beams is ignored.  An alternative is to define on the timing delay including the antenna phase center similar to Proposal3-1. |
| Apple | We share similar view as CATT/QC. |
| OPPO | Antenna array phase center offset is one of factors leading to the timing delay in gNB side. Usually, it is difficult to differentiate the time delay due to non-perfect synchronization, different RF chains or array phase centre offset. We think the solution to address group timing delay is also applicable for this case. |
| ZTE | Not really how this can be related to timing errors. In our understanding, the array phase center could be known to UE once antennas are mounted, so it’s up to UE’s implementation. And also compared with timing errors, this has small impact on positioning. |
| LG | Support for further study. We thinkthat this issue was not treated properly in the SI. |

## The spatial relation of SRS with DL PRS or SSB

Submitted Proposals

* (Ericsson [R1-2101754](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101754.doc))Proposal 2
  + 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 delay group.

FL comments

For the estimation UE TX timing error difference, it was proposed in [19] to configure an SRS with a spatial relation towards a DL PRS or SSB together with a certain delay group, in order to support the UE to transmit each SRS towards TRPs with each delay group (i.e., antenna panel).

Configure an SRS with a spatial relation towards a DL PRS or SSB is supported in Rel-16 without the consideration of the UE Tx timing errors. Adding the timing error group into consideration will obviously increase the difficulty and complexity. Suggest further discuss above proposed enhancement, including the potential benefits and implementation issues.

### Proposal 4-3

* Further study the configuration of an SRS with a spatial relation towards a DL PRS or SSB together with a Tx timing error group

Comments

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| **Company** | **Comments** |
| vivo | Same view as proposal 3-4, it seems to overlap with MIMO discussion. |
| Huawei/HiSilicon | We noticed that feMIMO WI is also discussing gNB configuring SRS Tx panel, and we would prefer to avoid duplicated discussion. |
| CATT | We share the same view with vivo and Huawei/HiSilicon, prefer to disucss this issue in feMIMO session. |
| Ericsson | In our understaning, FeMIMO will not discuss aspects related to Tx timing error groups. TEGs are to be discussed in ePos.  It should be noted that reporting TEG index with measurement works very well when there are many TRPs/many links since this methods rely on a reference TRP per TEG.  But in scenarios with limited number of links/TRPs, we think the proposed method in this proposal is beneficial. |
| Apple | If the intention is to make sure different SRS transmissions are on the panels/beams with similar Tx delay, we are ok to further study |
| OPPO | Since there are some proposals in other sections related to this one, postpone the discussion until we have a clear view whether and how Tx timing error group is defined/indicated/reported |
| ZTE | Prefer not to discuss in this WI. |
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## Beam and delay group sweeping

Submitted Proposals

* (Ericsson [R1-2101754](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101754.doc))Proposal 3
  + RAN1 should study beam and delay group 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.

It may increase significantly the overhead if there is both beam and delay group sweepings are used without introducing a proper method for managing the sweepings. Suggest further study the benefits, the methods, the configuration etc. for managing the situation that UL SRS resources (UL beams) may be transmitted with different Tx timing errors.

### Proposal 4-4

* Further study both beam and delay group sweeping and the reduction of positioning overhead

Comments

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| **Company** | **Comments** |
| vivo | Low priority, we think it should be discussed after the understanding, method and mechanism are clear |
| Huawei/HiSilicon | In our view, the current UE reporting “TEG” info to the LMF is sufficient. |
| CATT | We prefer this study as low priority in this meeting. |
| Nokia/NSB | We are not sure what exactly the proposal would entail. What is the specification impact? |
| Ericsson | It should be noted that reporting TEG index with measurement works very well when there are many TRPs/many links since this methods rely on a reference TRP per TEG.  But in scenarios with limited number of links/TRPs, we think the proposed method in this proposal is beneficial. |
| Apple | Low priority |
| OPPO | If some proposal in other section(s) (e.g., Proposal 3-4) is agreed, no need to discuss this solution  On the other hand, as for the Tx timing delay at gNB, is similar sweeping suggest for PRS transmission? |
| ZTE | Low priority issue |
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# Others

Submitted Proposals

* (CAICT [R1-2100308](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100308.doc))Proposal 3:
  + Beam related accuracy and multipath accuracy enhancement need to be further considered.
* (TCL [R1-2100697](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100697.doc))Proposal 1:
  + Support Closed-loop power control for the transmission of SRS for positioning.
* (TCL [R1-2100697](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100697.doc))Proposal 2:
  + Support transmission of assistance information to UEs switching between positioning systems to reduce position acquisition delay.
* (Samsung [R1-2101210](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101210.doc)) Proposal 2:
  + Improving the TA granularity should be support for TA report in E-CID.
* (Samsung [R1-2101210](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101210.doc)) Proposal 3:
  + Positioning in RRC inactive state should be supported.
* (China Telecom [R1-2101527](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101527.doc)) Proposal 1:
  + Rel-17 should support additional PRS RE mapping patterns with smaller DL PRS symbol lengths, including the 1-symbol PRS patterns.
* (China Telecom [R1-2101527](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101527.doc)) Proposal 2:
  + Rel-17 should support the DL PRS frequency domain multiplexed with other DL signals and channels in PRB-level.
* (China Telecom [R1-2101527](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101527.doc)) Proposal 3:
  + Rel-17 should support additional UL SRS for positioning RE mapping patterns with smaller PRS symbol lengths, i.e. the comb-4 and comb-8 for 1-symbol SRS patterns, the comb-8 for 2-symbol SRS pattern.

FL comments

The above proposals are discussing the positioning enhancements that are not included in the scope of Rel-17 WI objectives at this moment. Suggest considering these proposals as low priority in this meeting.

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| **Company** | **Comments** |
| CATT | Support these proposals as low priority in this meeting. |
| Nokia/NSB | Agree with FL. |
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# References

1. [R1-2100128](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100128.doc) Enhancement of timing-based positioning by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays OPPO
2. [R1-2100195](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100195.doc) Enhancement to mitigate gNB and UE Rx/Tx timing error Huawei, HiSilicon
3. [R1-2100293](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100293.doc) Positioning accuracy improvement by mitigating timing delay ZTE
4. [R1-2100308](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100308.doc) Discussion on accuracy improvements of NR positioning enhancements CAICT
5. [R1-2100385](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100385.doc) Discussion on accuracy improvements by mitigating UE Rx/Tx and/or gNB Rx/Tx timing delays CATT
6. [R1-2100445](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100445.doc) Discussion on methods for RX/TX timing delay mitigating vivo
7. [R1-2100548](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100548.doc) Initial views on mitigating UE and gNB Rx/Tx timing errors Nokia, Nokia Shanghai Bell
8. [R1-2100657](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100657.doc) Mitigation of UE and gNB Tx/Rx timing errors Intel Corporation
9. [R1-2100697](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100697.doc) Positioning enhancement by UE Assistance TCL Communication Ltd.
10. [R1-2100708](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100708.doc) Discussion on accuracy improvement by mitigating UE Rx/Tx and gNB Rx/Tx timing delays LG Electronics
11. [R1-2100752](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2100752.doc) Techniques to improve accuracy in the presence of UE Rx/Tx and/or gNB Rx/Tx timing delays InterDigital, Inc.
12. [R1-2101046](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101046.doc) Discussion on gNB/UE Rx/Tx timing delay mitigation solutions CMCC
13. [R1-2101131](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101131.doc) On methods for Rx/Tx timing delays mitigation Fraunhofer IIS, Fraunhofer HHI
14. [R1-2101140](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101140.doc) The mitigation of  RX/TX timing delays for higher accuracy MediaTek Inc.
15. [R1-2101210](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101210.doc) Discussion on accuracy improvements on timing based positioning solutions Samsung
16. [R1-2101387](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101387.doc) Positioning accuracy enhancements under UE and/or gNB Tx/Rx timing errors Apple
17. [R1-2101468](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101468.doc) Enhancements on Timing Error Mitigations for improved Accuracy Qualcomm Incorporated
18. [R1-2101527](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101527.doc) NR positioning enhancements by mitigating timing delays China Telecom
19. [R1-2101754](file:///E:\1%20Meetings\RAN1\2021_01_TSGR_104e\Docs\R1-2101754.doc) Techniques mitigating UE Rx/Tx timing delays Ericsson
20. RP-202900, “New WID on NR Positioning Enhancements”, CATT, Intel Corporation, Ericsson, December 7th – 11th, 2020.