**3GPP TSG RAN WG1 Meeting #106-e R1-xxxxxxx**

**E-meeting, August 16th – 27th, 2021**

**Agenda Item: 8.3.4**

**Source: Moderator (Huawei)**

**Title: Feature lead summary on propagation delay compensation enhancements**

**Document for: Discussion and Decision**

# Introduction

The revised IIoT / URLLC work item description for Rel-17 [1] has enhancements for time synchronization as one of its main objectives:

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| 1. Enhancements for support of time synchronization:
2. RAN impacts of SA2 work on uplink time synchronization for TSN, if any. [RAN2]
3. Propagation delay compensation enhancements (including mobility issues, if any). [RAN2, RAN1, RAN3, RAN4]
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This document summarizes the key issues discussed under agenda item 8.3.4 based on the views in [3][4][5][6][7][8][9][10][11][12][13][14], and aims to discuss a set of issues in RAN1#106-e. The agreements in past meetings are captured in the Appendix.

# Remaining issues on error components

There are several aspects which have impact on the timing accuracy between UE and gNB. In the previous meetings, we discussed the potential error components that would have impact on the time accuracy one by one, and achieved agreements on most of the error components as shown in the Appendix. One remaining issue is how to interpret the agreed value for BS transmit timing error.

## How to interpret the agreed value for BS transmit timing error

In RAN1#103-e, we have agreed to use 65 ns to represent the BS transmit timing error for the control-to-control scenario.

Agreements:

* Take 65 ns as the assumption of transmit timing error for evaluation of the overall time synchronization error for control-to-control.

In RAN1#104-e meeting, Nokia (R1-2100730) propose to clarify if this should be interpreted as a maximum (<) or a relative (±) value.

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| --- |
| Nokia R1-2100730The agreed number of 65ns originates from the TAE requirement from TS 38.104, where the TAE represents the relative maximum timing error between any two antenna ports (i.e. <65ns). So, our interpretation of the agreed value is to use <65ns which translates to ±32.5ns per gNB antenna port.**Proposal 1: The agreed 65ns value used to represent the BS frame transmission error should be interpreted as ±32.5ns to represent a single gNB antenna port frame transmission error for the control-to-control scenario.**  |

In RAN1#104-e meeting and RAN1#104b-e, the following was proposed based on inputs from companies with the corresponding status as below:

* ***errorBS,DL,TX (i.e. ±32.5 ns) is included in the equation for calculating the overall time synchronization for the control-to-control scenario.***
	+ **Support*:*** *CATT, Nokia/NSB, Vivo, ZTE, Intel, LG, Samsung, ETRI, Huawei/HiSilicon, MTK, ZTE*
	+ **Support ±65ns:** *OPPO (fine to follow the majority view for using 32.25ns if only one or two companies have concern)*
	+ **Strong concern:** *Ericsson, Qualcomm*
		- *65ns defined for TAE is used to represent BS transmit timing error due to lack of better standardized values, since it is expected that transmit timing error is approximated as ±65ns.*
		- *±65ns is a safer assumption because there is no guarantee for the correct DL Tx timing to stay at the middle of 65ns interval*
		- *The assumption for the previous agreements is ±65ns.*

In RAN1#106-e meeting, Nokia (R1-2106638) and vivo (R1-2106590) discuss this issue and propose ±32.5 ns.

**Feature lead:** this issue was already discussed in both RAN1#104-e meeting and RAN1#104b-e meeting, and unfortunately company positions keep no change and consensus cannot be achieved. It is expected that further email discussion won’t bring us anywhere, thus the issue will be considered as low priority for now, and later if necessary we can come back to this issue.

**Proposal 2.1-1: e*rrorBS,DL,TX* (i.e. ±32.5 ns) is included in the equation for calculating the overall time synchronization for the control-to-control scenario.**

# Evaluation on the achievable time synchronization accuracy over Uu interface in Rel-16

In order to evaluate whether any enhancements needed in Rel-17 to meet the requirement, we need the check the performance that can be achieved by Rel-16 mechanisms first.

The potential error components that will have impact on the time synchronization accuracy over Uu interface are as below:

* **BS transmit timing error (**:
	+ For control-to-control, it was agreed to use 65 ns for the evaluation.
	+ For smart grid, it was agreed to use 65ns or 200ns for the evaluation.
* **Downlink frame timing error ():**
	+ Based on the reply from RAN4, it is already included in Te
* **UE Initial transmit timing error (**Te**)** :
	+ The value defined in Table 7.1.2-1 for initial transmit timing error (Te) in TS 38.133



* **BS detecting error ()** :
	+ 100 ns
* **Asymmetry between downlink and uplink channel ()**:
	+ Not considered
* **TA indicating error ()**: Details as shown in section 3.2.3.3 in R1-2007068
	+ ±8\*64\*Tc/2μ
* **TA adjustment accuracy ()**:
	+ Not considered
* **Indication error**
	+ 5ns, it is already included in the network part budget.

## Equation to calculate the overall time synchronization error over Uu interface

In RAN1#104b-e meeting, the following 4 basic steps were made for better understanding how to get the equation to calculate the overall time synchronization error over Uu interface. It is common understanding that step 1 to step 3 are applied to both TA-based PDC and RTT-based PDC.

**Step 1**: gNB sends the reference time clock (i.e. *referenceTimeInfo-r16*) to UE, and the actual time clock at the UE side should be

* BS transmit timing error **for transmitting the RRC signaling containing the reference time clock**
* Downlink frame timing detection error **for receiving the RRC signaling contacting the reference time clock**



**Step 2**: When the UE receives *referenceTimeInfo-r16*, UE obtains indicated by *referenceTimeInfo-r16*. After UE does the propagation delay compensation, the estimated time clock at the UE side is

* DL propagation delay estimation error, e.g. for TA-based PDC. Note that details for is defined in step 4 below.

**Step 3**: The overall time synchronization error (i.e. the difference between the actual time clock in step 1 and the estimated time clock in step 2) is

**Step 4**: Discuss and determine error component(s) for DL propagation delay estimation (i.e. )

For TA-based PDC, the following working assumption were achieved in RAN1#104b-e:

Working assumption:



In RAN1#105-e meeting, RAN1 received the LS [15] from RAN4 to inform that downlink frame timing detection error is already included in UE transmit timing error (i.e. Te defined in section 7.1.2 in TS 38.133). Thus it is clear that , so the two alternatives in above WA can be updated as below:

* **Alt. 1**:

* **Alt. 2**:
	+ [Note: Alt.2 assumes that the time of PD estimation is close to the time of PD compensation, in which case the DL frame timing error and BS transmit timing error for propagation delay estimation is correlated to that for the transmission of RRC signaling carrying the reference time clock]

At this stage, I would recommend not to discuss and fight more on which alternative to choose, because the key question now is whether/how much it is feasible to reduce Te and TA indication granularity, which needs inputs from RAN4. For example, if based on the analysis from RAN4, Te and TA indication granularity cannot go down to meet the budget even with Alt.2 above, then there is no point to argue here.

## Overall time synchronization error over Uu interface in Rel-16

According to the LS from RAN2, the single Uu interface budget for control-to-control scenario and smart grid scenario are as shown below:

|  |  |
| --- | --- |
| **Scenario** | **Single Uu interface Budget** |
| Control-to-Control | ±145ns to ±275ns |
| Smart Grid | ±795ns to ±845ns |

In RAN1#104bis-e meeting, the following is agreed. Then it is clear that PDC based on existing Rel-15/Rel-16 TA procedure and associated granularity, with no enhancements in RAN1, is sufficient for smart grid, and RAN1 needs to further study and specify the feasible enhancement (if any with RAN1 spec impact) for propagation delay compensation for control-to-control scenario.

Agreements:

* Observation 1: Propagation delay compensation based on existing Rel-15/Rel-16 TA procedure and associated granularity, with no enhancements in RAN1, is sufficient for meeting the Uu interface synchronicity error budget in LS R2-2010837 for the smart grid scenario.
* Observation 2: RAN1 needs to further study and specify the feasible enhancement (if any with RAN1 spec impact) for propagation delay compensation for control-to-control scenario, in order to meet the synchronicity budget of Uu interface in LS R2-2010837.

Some papers submitted to RAN1#106-e discuss the overall time synchronization error over Uu interface in Rel-16 also. Since we already have the above two observations, there is no need to spend time on this aspect again.

# Potential enhancements for propagation delay compensation

In RAN1#102-e meeting, the following option 1 and option 2 are agreed for further study in RAN1.

* **Option 1**: TA-based propagation delay
	+ **Option 1a**: Propagation delay estimation based on legacy Timing advance (potentially with enhanced TA indication granularity).
	+ **Option 1b**: Propagation delay estimation based on timing advanced enhanced for time synchronization (as 1a but with updated RAN4 requirements to TA adjustment error and Te)
	+ **Option 1c:** Propagation delay estimation based on a new dedicated signaling with finer delay compensation granularity (Separated signaling from TA so that TA procedure is not affected)
* **Option 2**: RTT based delay compensation:
	+ Propagation delay estimation based on an RAN managed Rx-Tx procedure intended for time synchronization (FFS to expand or separate procedure/signaling to positioning).

## Common issues for enhancements for propagation delay compensation

There are some issues that are common for both RTT-based PDC and TA-based PDC.

**Issue 4.1-1: whether should be included in PD estimation errors?**

In RAN1#106-e meeting, Nokia (R1-2106638) propose to not include in PD estimation error. And ZTE (R1-2106738) propose to include in PD estimation error.

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| Nokia (R1-2106638)**Proposal 5: should only be accounted for in the SFN boundary estimation related errors and not in the PD estimation errors.**  |

|  |
| --- |
| ZTE (R1-2106738)***Proposal 2:*** *should be included in the DL propagation delay estimation error* |

**Feature lead:** In RAN1#104bis-e, we have already agreed a WA for two alternatives about the overall time synchronization error for TA based propagation delay compensation. Thus we don’t need to discuss whether should be included in PD estimation error or not. In addition, at this stage seems no point to argue on which alternative to choose, because the key question now is whether/how much it is feasible to reduce Te and TA indication granularity, which needs inputs from RAN4. For example, if based on the analysis from RAN4, Te and TA indication granularity cannot go down to meet the budget even with Alt.2 above, then there is no point to argue here.

## TA-based propagation delay compensation

This section will discuss some key issues for TA-based propagation delay compensation.

**Issue 4.2-1: Whether we need to use timing advance adjustment accuracy instead of Te for the evaluation of TA-based PDC?**

We already reached the following agreements below.

**RAN1#102-e**

Agreements:

The value defined in Table 7.1.2-1 for initial transmit timing error (Te) in TS 38.133 should be considered for evaluation of the time synchronization.

Agreements:

Timing advance adjustment accuracy defined in Table 7.3.2.2-1 in TS 38.133 is assumed for evaluation of the time synchronization.

**RAN1#103-e**

Agreements:

TA adjustment accuracy is not considered for the evaluation of time synchronization error.

**RAN1#104bis-e**

Agreement:

Take the following as the evaluation assumptions for both RTT-based PDC and TA-based PDC.

* The UE may acquire an up-to-date PD estimation after waking up from DRX. This implies that gNB may signal an update timing advance value or complete a Rx-Tx measurement procedure.
* *errorUE,DL,RX* is based on other signals (e.g. CSI-RS) instead of SSB.
* *errorBS, UL,RX* is based on other uplink signals instead of contention based PRACH, e.g. SRS.
* Further study and specify new procedure/signaling (if necessary) to ensure that the PD estimation can be acquired after DRX for the adopted PDC method.

In RAN1#106-e meeting, Nokia (R1-2106638) propose to use TA adjustment error instead of Te for evaluation, because based on RAN1#104-bis agreement the UE may acquire an up-to-data PD estimation after waking up from DRX.

**Feature lead**: this is related to the interpretation about the RAN4 spec marked in yellow below. However, I would like to recommend not to discuss it for now, because similar as the above, the key question now is whether/how much it is feasible to reduce Te, TA indication granularity and TA adjustment accuracy, which needs inputs from RAN4. For example, if based on the analysis from RAN4 there is no way to improve the TA adjustment accuracy, it is expected difficult to meet the budget by TA-based PDC also.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 7.1.2.1 Gradual timing adjustmentRequirements in this section shall apply regardless of whether the reference cell is on a carrier frequency subject to CCA or not. When the transmission timing error between the UE and the reference timing exceeds ±Te then the UE is required to adjust its timing to within ±Te. The reference timing shall be  before the downlink timing of the reference cell. All adjustments made to the UE uplink timing shall follow these rules:1) The maximum amount of the magnitude of the timing change in one adjustment shall be Tq.2) The minimum aggregate adjustment rate shall be Tp per second.3) The maximum aggregate adjustment rate shall be Tq per 200 ms. where the maximum autonomous time adjustment step Tq and the aggregate adjustment rate Tp are specified in Table 7.1.2.1-1.Table 7.1.2.1-1: Tq Maximum Autonomous Time Adjustment Step and Tp Minimum Aggregate Adjustment rate

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | SCS of uplink signals (kHz) | Tq | Tp  |
| 1 | 15 | 5.5\*64\*Tc | 5.5\*64\*Tc |
|  | 30 | 5.5\*64\*Tc | 5.5\*64\*Tc |
|  | 60 | 5.5\*64\*Tc | 5.5\*64\*Tc |
| 2 | 60 | 2.5\*64\*Tc | 2.5\*64\*Tc |
|  | 120 | 2.5\*64\*Tc | 2.5\*64\*Tc |
| NOTE: Tc is the basic timing unit defined in TS 38.211 [6] |

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**Issue 4.2-2: Required reduced Te and/or TA indication granularity for TA-based PDC**

Based on the discussion in previous meeting, it seems common understanding that option 1a itself cannot meet the requirement anyway even enhanced TA indication granularity is introduced. However, there are different views on whether combination of option 1a + option 1b or option 1c can meet the requirement or not, which would depend on how much Te and/or TA command indication granularity can be reduced, which are up to RAN4 though. Therefore, RAN1 needs to provide the required reduced Te and/or TA indication granularity needed to RAN4, then RAN4 can further evaluate whether/how it is feasible to achieve those reduced value for Te and/or TA command indication granularity.

Based on the contribution submitted to RAN1#106-e meeting, the reduced Te and/or TA indication granularity is summarized as shown in Table 4.2-1 below. For convenience, the two alternatives achieved based on the working assumption in RAN1#104bis and the LS reply from RAN4 as discussed in section 3.1 are copied here.

* **Alt. 1**:

* **Alt. 2-1**:
* **Alt. 2-2**:

Note that evaluations not using the alternatives in the working assumption are not included here in the table.

Table 4.2-1 Reduced Te and/or TA indication granularity needed for TA-based PDC to meet the requirement

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Source** | **SCS** | **Reduced Te** | **Reduced TA command indication granularity** | **overall synchronization error** | **Assumptions** |
| Intel(R1-2107587) | 15 kHz | (1/4)\* Te | (1/4)\* (16\*64\*Tc/2μ) | 328 | Equation Alt. 1 with 65 ns for  |
| 30 kHz | (1/4)\* Te | (1/4)\* (16\*64\*Tc/2μ) | 295 | Equation Alt. 1 with 65 ns for  |
| Huawei(R1-2107678) | 15 kHz | (0.1)\*Te | (1/16)\* (16\*64\*Tc/2μ) | 275 | Equation Alt. 1 with 65 ns for  |
| 30 kHz | (0.1)\*Te | (1/16)\* (16\*64\*Tc/2μ) | 265 |
| OPPO(R1-2107276) | 15 kHz | No change | No change | 573 | Equation Alt. 1 with 65 ns for  |
| CATT(R1-2106966) | 15 kHz | No change | No change | 813.75 | Equation Alt.1 with 32.5 ns for  |
| 30 kHz | No change | No change | 553.75 |
|  |
| Huawei(R1-2107678) | 15 kHz | (0.78)\*Te | (1/16)\* (16\*64\*Tc/2μ) | 275 | Equation Alt.2-1 with 65 ns for  |
| 30 kHz | (0.78)\*Te | (1/16)\* (16\*64\*Tc/2μ) | 220 |
| Intel(R1-2107587) | 15 kHz | (1/4)\* Te | (1/4)\* (16\*64\*Tc/2μ) | 196 | Equation Alt.2-1 with 65 ns for  |
| 30 kHz | (1/4)\* Te | (1/4)\* (16\*64\*Tc/2μ) | 164 |
| OPPO(R1-2107276) | 15 kHz | No change | No change | 441 | Equation Alt.2-1 with 65 ns for  |
| Qualcomm(R1-2107340) | 15 kHz | No change | No change | 546 | Equation Alt.2-1 with 65 ns for  |
| Vivo(R1-2106590) | 15 kHz | (4/5)\* Te: 312 ns | (1/4)\* (16\*64\*Tc/2μ): 65 ns | 271 | Equation Alt.2-1 with 32.5 ns for *Note: Alt.2-1 with 32.5 is equal to Alt.2-2 with 65* |
| 30 kHz | No change: 260 ns | (3/4)\* (16\*64\*Tc/2μ): 97.5 ns | 264 |
| CATT(R1-2106966) | 15 kHz | No change | No change | 407.5 | Equation Alt.2-1 with 32.5 ns for *Note: Alt.2-1 with 32.5 is equal to Alt.2-2 with 65* |
| 30 kHz | No change | No change | 277.5 |
|  |
| ZTE(R1-2106738) | 15 kHz | (1/2)\* Te | (1/2)\* (16\*64\*Tc/2μ) | 245 | Equation Alt.2-2 with 65 ns for *Note: Alt.2-1 with 32.5 is equal to Alt.2-2 with 65* |
| 30 kHz | No change | No change | 277.5 |
| Huawei(R1-2107678) | 15 kHz | (0.94)\*Te | (1/16)\* (16\*64\*Tc/2μ) | 274 | Equation Alt.2-2 with 65 ns for  |
| 30kHz | (0.94)\*Te | (1/16)\* (16\*64\*Tc/2μ) | 209 |
| OPPO(R1-2107276) | 15 kHz | No change | No change | 408 | Equation Alt.2-2 with 65 ns for  |

Based on the above table, it can be seen that if Te and/or TA command indication granularity can be reduced, there is some chance that TA-based PDC can meet the budget for control-to-control scenarios, of course depending on how much Te and TA command indication granularity can be reduced, which needs inputs from RAN4.

Based on the equations in Alt.1 & Alt.2 in the working assumption, the following table 4.2-2 can be achieved.

Table 4.2-2 Sum of Te and error from TA indication granularity for TA-based PDC to meet the single Uu interface budget

|  |  |
| --- | --- |
|  |  |
| ±275 ns single Uu interface budget | ±145 ns single Uu interface budget |
| Equation Alt. 1 | ~55 nse.g. (1/10)\*Te + (1/2)\*(1/16)\* (16\*64\*Tc/2μ) | N/A |
| Equation Alt. 2-1 | ~320 nse.g. (4/5)\*Te + (1/2)\*(1/16)\* (16\*64\*Tc/2μ) | ~60 nse.g. (1/10)\*Te + (1/2)\*(1/16)\* (16\*64\*Tc/2μ) |
| Equation Alt. 2-2 | ~385 nse.g. (9/10)\*Te + (1/2)\*(1/16)\* (16\*64\*Tc/2μ) | ~125 nse.g. (1/4)\*Te + (1/2)\*(1/16)\* (16\*64\*Tc/2μ) |

Note that (1/2)\*(1/16)\* (16\*64\*Tc/2μ) is used here for because it is assumed that at least the existing work in Release-16 for IAB for Timing Delta MAC CE can be reused, which can achieve 64\*Tc for FR1 for the indicating granularity.

### First round discussion for issue 4.2-2

For TA-based PDC, we really need to send LS to RAN4. Hopefully all can be constructive and let’s work together to get the LS out. If ideally we can get the LS back in time, then still there is chance for us to complete TA-based PDC in Rel-17, though indeed it is expected very challenging.

**Proposal 4.2-1: Send LS to RAN4 to ask for feedback on the following questions:**

* **Question 1**: Is it feasible to assume a smaller value than the current Te for the use of propagation delay compensation, assuming the same definition of Te in the current RAN4 specification or new definition/procedure? If the answer is yes, please also provide feedback on how much it can be reduced **at most**, e.g., some value in the range of [(1/10) \* Te, (9/10) \* Te].
* **Question 2**: Is it feasible to introduce enhanced TA command indication granularity and enhanced TA estimation accuracy? If the answer is yes, please also provide feedback on how much it can be reduced **at most**, e.g. reduced to (1/16)\* (16\*64\*Tc/2μ) for enhanced TA command indication granularity.
* Note : The alternatives in the working assumption achieved in RAN1#104bis-e together with the examples in Table 4.2-2 will be included in the LS to give some background for RAN4

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| --- | --- |
| *Company* | *View* |
| **Feature lead** | 1. As defined in Table 7.1.2-1 in TS 38.133 below, the existing Te is given based on SSB. It is expected that if some new reference signal, e.g. TRS, can be used then it is possible to achieve smaller value of Te, since wider bandwidth is available for TRS. Table 7.1.2-1: Te Timing Error Limit

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | SCS of SSB signals (kHz) | SCS of uplink signals (kHz) | Te |
| 1 | 15 | 15 | 12\*64\*Tc |
| 30 | 10\*64\*Tc |
| 60 | 10\*64\*Tc |
| 30 | 15 | 8\*64\*Tc |
| 30 | 8\*64\*Tc |
| 60 | 7\*64\*Tc |
| 2 | 120 | 60 | 3.5\*64\*Tc |
| 120 | 3.5\*64\*Tc |
| 240 | 60 | 3\*64\*Tc |
| 120 | 3\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 [6] |

 |
| CATT | We are fine with FL proposal. |
| Ericsson | We do not object to sending LS to RAN4 to ask for potential enhancements of Te and TA command indication. However, the questions phrased above are confusing.For Question 1, based on the RAN4 reasoning that led to the standardized values of Te (e.g., R4-1711514 Qualcomm, R4-1713648 Ericsson), Te value is obtained by adding some margin to the minimum DL frame timing detection error. The minimum DL frame timing detection error (without any margin) is inverse of the DL BW of the signals used for timing estimation. For Te, SSB is used as DL signal for timing estimation. Thus, if Te is to be reduced, typically a DL signal with wider bandwidth than SSB is expected. But “assuming the same definition of Te” means that RAN4 should estimate the possible reduced value of Te,new based on SSB as before. Thus, clarification text can be added to Question 1: “RAN4 can take the following assumptions: Existing conditions in Te requirement applies, including: “The UE shall meet the Te requirement for an initial transmission provided that at least one SSB is available at the UE during the last 160 ms.” [38.133].”Feature lead>> Update the proposal accordingly. For the sentence “The UE shall meet the Te requirement for an initial transmission provided that at least one SSB is available at the UE during the last 160 ms.”, I think it should be included in the existing conditions, thus no need to specifically spell it out. For Question 2, the assumptions for potentially reduced TA command granularity should be clarified. Currently, the TA command granularity (e.g., ±260 ns (= ±8\*64\*Tc) for SCS=15 kHz, ±130 ns (±4\*64\*Tc) for SCS=30kHz, etc) correspond to the time error tolerance of PRACH detection (e.g., 520 ns and 260ns for SCS=15 kHz and 30 kHz, respectively), see Table 8.4.2.1-1 of 38.104. If RAN4 is asked to check potentially reduced TA command granularity, it should be clarified if existing PRACH is assumed, or a new PRACH of wider bandwidth can be introduced for time sync purpose. It is noted that wider bandwidth PRACH was adopted for NR-U, i.e., length 571 and length 1151 PRACH sequence for unlicensed band). Thus clarification text can be added to Question 2: “Exiting definition of Timing Advance Command MAC CE (not “Absolute Timing Advance Command MAC CE”) is assumed, where the timing advance command is contained in Random Access Response. If a PRACH of wider bandwidth is needed for the gNB to achieve the reduced TA command granularity, please provide info on the corresponding PRACH that UE should use.” Feature lead>> I think the above clarification is mainly on TA adjustment accuracy. After further thinking, I think we can remove TA adjustment accuracy for now, since the main point now is whether/how much to reduce Te and TA indication granularity. In addition, I still add something to make it more clear the reference for the exact valueFor both Question 1 and 2: It should also be clarified that RAN1 are interested in SCS={15, 30} kHz. Thus: “Both SCS15 kHz and 30 kHz are assumed for both control-to-control and smart grid for evaluation of the time synchronization (RAN1#102e agreement).”Feature lead>> Update accordingly. |
| Nokia, NSB | Support.We would have preferred to apply Recommendation 3 to ensure that RAN1 can select a PDC method timely for RAN2 to finish the PDC framework for R17. But it seems that pursuing enhancements to legacy TA is still having significant support in RAN1, hence an LS is needed to clarify the feasibility.An enhancement to TA requirements would not come without implications to e.g. DL and UL reference signal bandwidth associated to the requirement, so we would propose that the LS also asks RAN4 on the assumptions related to that.Feature lead>> Agree, but I guess ok to update a little bit to make it clearer to RAN4 and also address concern from companies.  |
| ZTE | We are fine with the proposal.BTW, there is no further discussion on the two alternatives for TA-based solution, e.g. further evaluation or something. Is the FL intention that RAN1 will further discuss TA-based solution only after receiving the reply LS from RAN4 if this LS is approved?Feature lead>> The high priority now is to send the LS to RAN4 for TA-based PDC for now. Without input from RAN4, it seems further discussion will not bring us anywhere. However, we can see the situation later to see if anything independent of the inputs from RAN4 can be discussed.  |
| Vivo | We are fine with FL proposal. |
| HW/HiSi | Support the proposal |
| LG | Support the proposal |
| Qualcomm | We do not support this proposal. We prefer a separate and clear design for PDC with no touching on the existing TA solution.Feature lead>> Understand your position. But it is fair to let RAN4 check the feasibility for TA-based PDC also. In addition, if the LS not out, then it is expected the progress for RTT based would be difficult also.  |

### Second round discussion for issue 4.2-2

Based on the inputs in section 4.2.1, the proposal is revised as below. **Please all companies check the reply from me in section 4.2.1 to understand the reason to make the change**.

**Revised Proposal 4.2-1: Send LS to RAN4 to ask for feedback on the following questions:**

* **Question 1**: Is it feasible to assume a smaller value than the current Te for the use of propagation delay compensation, assuming the existing conditions in TS 38.133 for Te requirement or new conditions (e.g. using TRS instead of SSB)? If the answer is yes, please also provide feedback on how much it can be reduced **at most**, e.g., some value in the range of [(1/10) \* Te, (9/10) \* Te].
* **Question 2**: Is it feasible to introduce enhanced TA command indication granularity? If the answer is yes, please also provide feedback on how much it can be reduced **at most**, e.g. reduced to (1/16)\* (16\*64\*Tc/2μ) similar as the granularity for Rel-16 IAB based on the Timing Delta MAC CE.
* Note: Both SCS15 kHz and 30 kHz are assumed for both control-to-control and smart grid for evaluation of the time synchronization (RAN1#102e agreement).
* Note : The alternatives in the working assumption achieved in RAN1#104bis-e together with the examples in Table 4.2-2 will be included in the LS to give some background for RAN4

|  |  |
| --- | --- |
| *Company* | *View* |
| **Feature lead** | 1. As defined in Table 7.1.2-1 in TS 38.133 below, the existing Te is given based on SSB. It is expected that if some new reference signal, e.g. TRS, can be used then it is possible to achieve smaller value of Te, since wider bandwidth is available for TRS. Table 7.1.2-1: Te Timing Error Limit

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | SCS of SSB signals (kHz) | SCS of uplink signals (kHz) | Te |
| 1 | 15 | 15 | 12\*64\*Tc |
| 30 | 10\*64\*Tc |
| 60 | 10\*64\*Tc |
| 30 | 15 | 8\*64\*Tc |
| 30 | 8\*64\*Tc |
| 60 | 7\*64\*Tc |
| 2 | 120 | 60 | 3.5\*64\*Tc |
| 120 | 3.5\*64\*Tc |
| 240 | 60 | 3\*64\*Tc |
| 120 | 3\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 [6] |

 |
| Qualcomm | We do not support this proposal. We prefer a separate and clear design for PDC with no touching on the existing TA solution.Feature lead>> Understand your position. But it is fair to let RAN4 check the feasibility for TA-based PDC also. In addition, if the LS not out, then it is expected the progress for RTT based would be difficult also. |
| Intel | For Round 1 and Round 2, we would like to clarify that agreeing to send this LS should not pause discussion on RTT-based method. We think that the potential LS reply would be received quite late for RAN1 to take actions, regardless of the reply content.In summary, we agree to send this LS based on condition that RAN1 continues design of non-TA based PDC.Feature lead>> Thanks.  |
| OPPO | Even though we do not object in general the attempt of sending a LS to RAN4, we would like to get a clarification for the value of sending such a LS and we also have concern on the detailed LS language as proposed above. * Given RAN1 already has some solutions not requiring change of RAN4 hardware requirement, what is the benefit in using TA-based PDC to justify the complexity in supporting additional UE hardware requirements?

Feature lead>> Since different companies have different view on the feasibility, including whether it will have impact on hardware or not, we need to let RAN4 to check the feasibility. * When waiting for response from RAN4, would RAN1 stop progress on other solutions (like RTT-based and implicit PDC)?

Feature lead>> No. RAN1 will continue discuss the necessary issues for other solutions, including RTT-based and implicit PDC. In addition, what does it mean by asking “Is it feasible to assume …”? Does it mean RAN4 just need to assume something but not putting it into RAN4 spec? If so, is this something the implementation can rely on? Feature lead>> If you feel the word “assume” is not clear enough, we can use “support” instead. If is feasible, then for sure it will be capture in the specification also.  |
| CATT | We support this proposal. |
| Samsung | Fine with the proposal. If LS can be sent, we’d like to also inform RAN 4 that this may not impact on TA related procedure including requirement. Feature lead>> I think it depends on which option for TA-based PDC is adopted. But let me add a question to check the views from companies.  |
| vivo | We support this proposal. |
|  |  |

### Third round discussion for issue 4.2-2

Based on the inputs in section 4.2.1 & section 4.2.2, the proposal is revised as below. **Please all companies check the replies from me in section 4.2.1 & section 4.2.2 to understand the reason to make the change**.

**Revised Proposal 4.2-1: Send LS to RAN4 to ask for feedback on the following questions:**

* **Question 1**: Is it feasible to support a smaller value than the current Te for the use of propagation delay compensation, assuming the existing conditions in TS 38.133 for Te requirement or new conditions (e.g. using TRS instead of SSB)? If the answer is yes, please also provide feedback on how much it can be reduced **at most**, e.g., some value in the range of [(1/10) \* Te, (9/10) \* Te].
* **Question 2**: Is it feasible to introduce enhanced TA command indication granularity? If the answer is yes, please also provide feedback on how much it can be reduced **at most**, e.g. reduced to (1/16)\* (16\*64\*Tc/2μ) similar as the granularity for Rel-16 IAB based on the Timing Delta MAC CE.
* Note 1 : The alternatives in the working assumption achieved in RAN1#104bis-e together with the examples in Table 4.2-2 will be included in the LS to give some background for RAN4
* Note 2: The agreement “both SCS 15 kHz and 30 kHz are assumed for both control-to-control and smart grid for evaluation of the time synchronization” achieved in RAN1#102-e will be included in the LS for RAN4 information also.

**Please comment if you have strong concern with the proposal 4.2-1 here.**

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| *Company* | *View* |
| **Feature lead** | 1. As defined in Table 7.1.2-1 in TS 38.133 below, the existing Te is given based on SSB. It is expected that if some new reference signal, e.g. TRS, can be used then it is possible to achieve smaller value of Te, since wider bandwidth is available for TRS. Table 7.1.2-1: Te Timing Error Limit

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | SCS of SSB signals (kHz) | SCS of uplink signals (kHz) | Te |
| 1 | 15 | 15 | 12\*64\*Tc |
| 30 | 10\*64\*Tc |
| 60 | 10\*64\*Tc |
| 30 | 15 | 8\*64\*Tc |
| 30 | 8\*64\*Tc |
| 60 | 7\*64\*Tc |
| 2 | 120 | 60 | 3.5\*64\*Tc |
| 120 | 3.5\*64\*Tc |
| 240 | 60 | 3\*64\*Tc |
| 120 | 3\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 [6] |

2. Please check the replies to companies’ comments to understand better the revision here.  |
| Nokia, NSB | We are fine with the updated proposal. |
| Vivo | We are fine with the updated proposal. |
| CATT | We are fine with FL proposal. |
| Intel | We agree to send this LS based on condition that RAN1 continues design of non-TA based PDC |
| ZTE | We are fine with the proposal. |
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**Revised Question 4.2-1: Do you agree to include Note 3 as below to the LS also?**

* Note 3: Inform RAN4 that the enhancements on Te and TA command indication granularity for propagation delay compensation may or may not have impact on normal TA related procedure including requirements, depending on which candidate option for TA-based PDC is adopted~~, e.g. if option 1c for TA-based PDC is adopted then there is no impact~~. Note that this is just for RAN4 information.

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| *Company* | *View* |
| **Feature lead** | The above note 3 is added per the comment from Samsung. Please share your views on the note. @ Nokia @ vivo @ CATT @ Intel @ ZTE @ QualcommPlease check if you can accept the revised note 3 per the suggestion from Samsung.  |
| Nokia, NSB | We prefer not to add the note, as the questions are explicitly related to Te and TA command indication, and not to a new indication separated from TA as implied by option 1c.  |
| vivo | We share the same view with Nokia. The LS mainly focuses on the feasibility of the improved Te and TA command indication instead of the new signalling indication.  |
| CATT | We have the same view with VIVO and Nokia. |
| Intel | No need to include. If RAN4 sees issues with modifying the TA existing procedure to achieve the tighter Te and TA granularity values then they can include these considerations into the reply LS. |
| ZTE | We share the same view that the note is not needed. |
| Samsung | To resolve companies’ concern, we propose the update: * Note 3: Inform RAN4 that the enhancements on Te and TA command indication granularity for propagation delay compensation may or may not have impact on normal TA related procedure including requirements, depending on which candidate option for TA-based PDC is adopted~~, e.g. if option 1c for TA-based PDC is adopted then there is no impact.~~

We think this is the fact, and better to let them know, in case the concern from RAN 4 is related from TA requirement, since we can decouple them. Feature lead>> Update accordingly. Let's see the views from companies.  |
| Qualcomm | We do not think it is not helpful to include Note 3. |
| Nokia/NSB2 | Thanks for the updates. This is definitely better, but based on Note 3, are we then implicitly requesting RAN4 to consider 4 options, namely (i) impact on TA procedure but no new setting requirements, (ii) impact to TA procedure but no new requirements, (iii) no impact on TA but new requirements and (iv) no impact to TA but no requirements?Feature lead>> The intention is not to add additional work to RAN4, but just for RAN4 information. Just in case if they feel no chance to do the enhancement due to potential impact on normal TA procedure, let them know that there is candidate option without impact on normal TA procedure also. Maybe we can add more description in the note to clarify that this is just for RAN4 information.  |
| CATT | First of all, RAN4 need check whether accuracy of parameters on TA-PDC can be improved or not. If RAN4 give positive feedback, RAN1 can further discuss about whether current TA procedure can be impact or not.Feature lead>> Agree that the key thing for RAN4 is to check whether it is feasible to do the enhancements. But please check my reply to Nokia above and see whether it makes sense to you.  |
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**Outcome of Friday GTW session for issue 4.2-2**

**Agreement**

**Send LS to RAN4 to ask for feedback on the following questions:**

* **Question 1**: Is it feasible to support a smaller value than the current Te for the use of propagation delay compensation, assuming the existing conditions in TS 38.133 for Te requirement? If not, is it feasible under new conditions (e.g. using TRS instead of SSB)? If the answer is yes, please also provide feedback on how much it can be reduced **at most**.
* **Question 2**: Is it feasible to introduce enhanced TA command indication granularity? If the answer is yes, please also provide feedback on how much it can be reduced **at most (**e.g. reduced to (1/16)\* (16\*64\*Tc/2μ)**)** similar as the granularity for Rel-16 IAB based on the Timing Delta MAC CE **and related condition**.
* Note 1: The alternatives in the working assumption achieved in RAN1#104bis-e together with the examples in Table 4.2-2 will be included in the LS to give some background for RAN4
* Note 2: The agreement “both SCS 15 kHz and 30 kHz are assumed for both control-to-control and smart grid for evaluation of the time synchronization” achieved in RAN1#102-e will be included in the LS for RAN4 information also.
* Note 3: Inform RAN4 that the enhancements on Te and TA command indication granularity for propagation delay compensation may or may not have impact on normal TA related procedure, depending on which candidate option for TA-based PDC is adopted. Note that this is just for RAN4 information.
* Note 4: Whether RAN1 will introduce specification enhancements is still undetermined.

### 4th round discussion for issue 4.2-2

The following agreement was achieved during Friday GTW in the first week:

**Agreement**

**Send LS to RAN4 to ask for feedback on the following questions:**

* **Question 1**: Is it feasible to support a smaller value than the current Te for the use of propagation delay compensation, assuming the existing conditions in TS 38.133 for Te requirement? If not, is it feasible under new conditions (e.g. using TRS instead of SSB)? If the answer is yes, please also provide feedback on how much it can be reduced **at most**.
* **Question 2**: Is it feasible to introduce enhanced TA command indication granularity? If the answer is yes, please also provide feedback on how much it can be reduced **at most (**e.g. reduced to (1/16)\* (16\*64\*Tc/2μ)**)** similar as the granularity for Rel-16 IAB based on the Timing Delta MAC CE **and related condition**.
* Note 1: The alternatives in the working assumption achieved in RAN1#104bis-e together with the examples in Table 4.2-2 will be included in the LS to give some background for RAN4
* Note 2: The agreement “both SCS 15 kHz and 30 kHz are assumed for both control-to-control and smart grid for evaluation of the time synchronization” achieved in RAN1#102-e will be included in the LS for RAN4 information also.
* Note 3: Inform RAN4 that the enhancements on Te and TA command indication granularity for propagation delay compensation may or may not have impact on normal TA related procedure, depending on which candidate option for TA-based PDC is adopted. Note that this is just for RAN4 information.
* Note 4: Whether RAN1 will introduce specification enhancements is still undetermined.

**Please check and comment the** [**draft LS**](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_106-e/Inbox/drafts/8.3.4/4th%20round/R1-21xxxxx%20Draft%20LS%20on%20TA-based%20propagation%20delay%20compensation_v000.doc) **for issue #4.2-2.**

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| ***Company*** | ***View*** |
| ZTE | We are fine with the draft LS. |
| OPPO | The latest RAN4 LS (on Te interpretation) can only [equivalently] change the formula in RAN1 WA, but not the note. The corresponding texts in the proposed LS should be revised as following (because FL copied the formula+note as non-editable figure, I cannot remove the note. Anyhow our preference is to remove the note under Alt 2, which is anyway different from the note in original RAN1 WA): Note that the formula in the two alternatives in the above working assumption can be modified as below based on the LS reply R4-2105850 from RAN4: |
| Nokia/NSB | We are fine with the draft LS. |
| vivo | We are fine with the draft LS. |
| HwHiSi | Support |
| Samsung | Fine |

## RTT based propagation delay compensation

For RTT based delay compensation, propagation delay estimation is based on an RAN managed Rx-Tx procedure intended for time synchronization.

**Issue 4.3-1: Equation to calculate the overall time synchronization error over Uu interface for RTT-based PDC?**

As discussed in section 3.1, step 1 to step 3 should be common for both RTT-based PDC and TA-based PDC, and the difference is the detailed equation for .

**Step 4a**: Discuss and determine error component(s) for DL propagation delay estimation (i.e. )

for RTT-based compensation.



For RTT based delay compensation, propagation delay estimation is based on the RAN managed Rx-Tx procedure. **Note that the ones highlight in Red below needs to be further discussed**.





* + is to reflect the error due to report granularity of Rx-Tx time difference
	+ and reflects the measurement inaccuracy of gNB Rx-Tx time difference, and the measurement inaccuracy of UE Rx-Tx time difference, respectively.
	+ is to reflect the error due to the granularity of propagation delay indication, **and it is applied only for gNB-based RTT, i.e. it is not needed for UE-based RTT**.

**Feature lead:** The views on the equation is very diverse as summarized in the table below based on the contributions submitted to RAN1#106-e, thus we have to discuss with the questions in section 4.3.1 to achieve common understanding one-by-one.

### First round & Second round discussion for issue 4.3-1

**Proposals not changed based on first round email discussion yet. Companies are encouraged to check the replies and provide your further comments if any.**

The first issue is whether to consider UE and BS transmit timing error. According to the definition for Rx – Tx time difference below, the reference point for transmit measurement is antenna connector as highlight in yellow below, it seems in this case and don’t need to be considered. However, companies view are needed before making any decision here.

Similarly, whether to include and also need to be discussed. Based on the definition highlight in blue, since it is defined by the first detected path, it seems and need to be considered. **However, the question is whether these two errors are already included in the measurement accuracy defined in RAN4**, if yes then there is no need to include these two errors separately again.

5.1.30 UE Rx – Tx time difference

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| **Definition** | The UE Rx – Tx time difference is defined as TUE-RX –TUE-TXWhere:TUE-RX is the UE received timing of downlink subframe #*i* from a Transmission Point (TP) [18], defined by the first detected path in time.TUE-TX is the UE transmit timing of uplink subframe #*j* that is closest in time to the subframe #i received from the TP.Multiple DL PRS resources can be used to determine the start of one subframe of the first arrival path of the TP.For frequency range 1, the reference point for TUE-RX measurement shall be the Rx antenna connector of the UE and the reference point for TUE-TX measurement shall be the Tx antenna connector of the UE. For frequency range 2, the reference point for TUE‑RX measurement shall be the Rx antenna of the UE and the reference point for TUE‑TX measurement shall be the Tx antenna of the UE. |
| **Applicable for** | RRC\_CONNECTED |

5.2.3 gNB Rx – Tx time difference

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| --- | --- |
| **Definition** | The gNB Rx – Tx time difference is defined as TgNB-RX –TgNB-TXWhere:TgNB-RX is the Transmission and Reception Point (TRP) [18] received timing of uplink subframe #*i* containing SRS associated with UE, defined by the first detected path in time.TgNB-TX is the TRP transmit timing of downlink subframe #*j* that is closest in time to the subframe #*i* received from the UE.Multiple SRS resources for positioning can be used to determine the start of one subframe containing SRS.The reference point for TgNB-RX shall be:- for type 1-C base station TS 38.104 [9]: the Rx antenna connector,- for type 1-O or 2-O base station TS 38.104 [9]: the Rx antenna (i.e. the centre location of the radiating region of the Rx antenna),- for type 1-H base station TS 38.104 [9]: the Rx Transceiver Array Boundary connector.The reference point for TgNB-TX shall be:- for type 1-C base station TS 38.104 [9]: the Tx antenna connector,- for type 1-O or 2-O base station TS 38.104 [9]: the Tx antenna (i.e. the centre location of the radiating region of the Tx antenna),- for type 1-H base station TS 38.104 [9]: the Tx Transceiver Array Boundary connector. |

**Question 4.3-1: Do you agree that there is no need to include and**  **for DL propagation delay estimation error for RTT-based PDC? Please provide your reason also.**

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| --- | --- |
| *Company* | *View* |
| **Feature lead** | According to the definition for Rx – Tx time difference above, the reference point for transmit measurement is antenna connector as highlight in yellow below, it seems in this case and don’t need to be considered.*Note that here is just to say there is no need to include these two errors for DL propagation delay estimation . For the overall synchronization error these errors should still be considered as discussed in step 3 in section 3.1.*  |
| CATT | Based on our formula derivation, and should be considered.Feature lead>> According to the definition in RAN4 spec, the reference point for TUE-RX measurement shall be the Rx antenna connector of the UE and the reference point for TUE-TX measurement shall be the Tx antenna connector of the UE. Therefore, it doesn't matter whether there is any error for the uplink transmit timing compared to the DL frame timing. Note that we define for TA-based PDC (i.e.) would also include the potential error of DL frame timing error as replied by RAN4. As to the potential transmit timing error introduced due to UE internal implementation, e.g. time interval between baseband and antenna connector, it is expected that these kind of errors will be included in the Rx-Tx time difference accuracy.  |
| Ericsson | We believe and (NOTE: not ) need to be considered, assuming the UE receives reference time clock (e.g., *referenceTimeInfo-r16*) and performs propagation delay compensation. That is, these error components are the timing error for receiving the DL signal carrying *referenceTimeInfo-r16*. They exist irrespective of which method is used to estimate PDC, since they are outside of PDC error.Feature lead>> As highlight in blue above in the first row, here is only for estimation of PD, not the overall synchronization error. I think the logic and proposal here is aligned with your proposals, you can tell that from proposal 4.3.1-1 below.  |
| Nokia, NSB | AgreeThe Rx-Tx measurement requires the gNB and UE to timestamp the exact time of transmission. On the other hand, the TX errors are to reflect applicability of UL transmission time based on an inaccurately applied TA (at the UE) and TAE at the gNB which does not affect the capability to timestamp the time of transmission. |
| ZTE | Even though the defined reference point for the measurment is antenna connector, it does not mean that we do not need to consider the transmitting time error for DL propagation delay estimation error. The transmitting time error leads to the transmitter does not know exactly the transmission time of the signal at the Tx antenna connecter. Therefore, they should be considered.Feature lead>> According to the definition in RAN4 spec, the reference point for TUE-RX measurement shall be the Rx antenna connector of the UE and the reference point for TUE-TX measurement shall be the Tx antenna connector of the UE. Therefore, it doesn't matter whether there is any error for the uplink transmit timing compared to the DL frame timing. Note that we define for TA-based PDC (i.e.) would also include the potential error of DL frame timing error as replied by RAN4. As to the potential transmit timing error introduced due to UE internal implementation, e.g. time interval between baseband and antenna connector, it is expected that these kind of errors will be included in the Rx-Tx time difference accuracy.  |
| Vivo | For UE Rx-Tx time difference, should be included for DL propagation delay estimation error for RTT based PDC because the gNB DL transmit error was not taken into UE Rx-Tx time difference measurement accuracy requirements.Accordingly, for gNB Rx-Tx time difference, should be included for DL propagation delay estimation error for RTT based PDC because the UE uplink transmit error was not taken into gNB Rx-Tx time difference measurement accuracy requirements.Feature lead>> According to the definition in RAN4 spec, the reference point for TUE-RX measurement shall be the Rx antenna connector of the UE and the reference point for TUE-TX measurement shall be the Tx antenna connector of the UE. Therefore, it doesn't matter whether there is any error for the uplink transmit timing compared to the DL frame timing. Note that we define for TA-based PDC (i.e.) would also include the potential error of DL frame timing error as replied by RAN4. As to the potential transmit timing error introduced due to UE internal implementation, e.g. time interval between baseband and antenna connector, it is expected that these kind of errors will be included in the Rx-Tx time difference accuracy.  |
| Hw/HiSi | Agree that there is no need to include and for the DL propagation delay estimation error. The reason is that the UE Rx-Tx time difference and the gNB Rx-Tx time difference as defined in TS38.215 are using the antenna connector as the reference point for UE-TX measurement and gNB-TX measurement. |
| LG | Support. We agree that there is no need to add separated error component since error components could be combined by setting reference point each other. Especially if error indication can be measured/assumed regardless of frame timing, that should be fine. |
| Qualcomm | As described in our contribution, and should be considered for total error.Feature lead>> As highlight in blue above in the first row, here is only for estimation of PD, not the overall synchronization error. For the overall synchronization error these errors should still be considered as discussed in step 3 in section 3.1. |
| Intel | We believe the fact that the measurements are defined using the antenna connector as a reference point does not lead to the assumption that the mentioned error components are not considered.The other question would be whether these error components can be eliminated by the UE and gNB when calculating RX-TX time difference, and here the answer would be ‘yes’.Feature lead>> According to the definition in RAN4 spec, the reference point for TUE-RX measurement shall be the Rx antenna connector of the UE and the reference point for TUE-TX measurement shall be the Tx antenna connector of the UE. Therefore, it doesn't matter whether there is any error for the uplink transmit timing compared to the DL frame timing. Note that we define for TA-based PDC (i.e.) would also include the potential error of DL frame timing error as replied by RAN4. As to the potential transmit timing error introduced due to UE internal implementation, e.g. time interval between baseband and antenna connector, it is expected that these kind of errors will be included in the Rx-Tx time difference accuracy.  |
| OPPO | Disagree. We do not think the reference point of DL-Tx (and UL-Tx) at antenna connector can necessarily remove (and ). “Reference point” means the RTT being measured terminates at that reference point, but it does not necessarily require the actual measurement be done at that point. It is more likely that the timing measurements of DL-Tx and UL-Tx are performed in digital domain, i.e., in baseband, meanwhile taking into account the signal travel time interval between baseband and antenna connector, which is UE implementation benchmark. Feature lead>> According to the definition in RAN4 spec, the reference point for TUE-RX measurement shall be the Rx antenna connector of the UE and the reference point for TUE-TX measurement shall be the Tx antenna connector of the UE. Therefore, it doesn't matter whether there is any error for the uplink transmit timing compared to the DL frame timing. Note that we define for TA-based PDC (i.e.) would also include the potential error of DL frame timing error as replied by RAN4. As to the potential transmit timing error introduced due to UE internal implementation, e.g. time interval between baseband and antenna connector, it is expected that these kind of errors will be included in the Rx-Tx time difference accuracy. Another issue we would like to raise: whether the estimated PD that terminates at antenna connector can be used to compensate the PD that is assumed by RAN2 to terminate at other places when working with TimeReferenceInfo? Below is what 38.331 says for “time” field in TimeReferenceInfo:“*The indicated time is referenced at the network, i.e., without compensating for RF propagation delay. …… If the referenceTimeInfo field is received in DLInformationTransfer message, the time field indicates the time at the ending boundary of the system frame indicated by referenceSFN.* ” There is no hint that the measurement for TimeReferenceInfo should take reference point at antenna connector. It seems the PD estimation step and PD compensation step deal with different variations of PD (with different reference points). Then how to use one to compensate another ? Feature lead>> From step 1 to step 3 in section 3.1, we can tell that there is no need to apply the same reference point (i.e. antenna connector) to receive TimeReferenceInfo, since and used there to reflect the potential error components introduced by receiving the reference time. However, for estimation of error brought by propagation delay, i.e. , the reference point can be different from the one receiving the reference time, of course in this case the errors due to receiving the referent time and estimation of propagation delay is independent.   |
| Samsung | We think the following equation should be used. But we are open to discuss on the value of each component. Feature lead>> According to the definition in RAN4 spec, the reference point for TUE-RX measurement shall be the Rx antenna connector of the UE and the reference point for TUE-TX measurement shall be the Tx antenna connector of the UE. Therefore, it doesn't matter whether there is any error for the uplink transmit timing compared to the DL frame timing. Note that we define for TA-based PDC (i.e.) would also include the potential error of DL frame timing error as replied by RAN4. As to the potential transmit timing error introduced due to UE internal implementation, e.g. time interval between baseband and antenna connector, it is expected that these kind of errors will be included in the Rx-Tx time difference accuracy. |
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**Question 4.3-2: Do you agree that we only need to include one of the following two component combinations for DL propagation delay estimation error for RTT-based PDC? If yes, please provide which component combination you prefer and your reason.**

* + **Component combination 1**: +
	+ **Component combination 2:**  +, where and reflects the measurement inaccuracy of gNB Rx-Tx time difference, and the measurement inaccuracy of UE Rx-Tx time difference, respectively.

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| *Company* | *View* |
| **Feature lead**  | Based on the definition highlight in blue above for the time different definition in RAN4, since it is defined by the first detected path, it seems and need to be considered. However, the question is whether these two errors are already included in the measurement accuracy defined in RAN4, if yes then there is no need to include these two errors separately again.On the other hand, if we include and in the equation, then we may don’t need to consider and again. Note that RAN4 is discussing time difference definition for PRS for positioning, in theory RAN4 should define similar measurement accuracy for RTT-based PDC also. If and will be defined in RAN4 for RTT-based PDC, then it seems more accurate to use and since it may reflect other errors also in addition to and . |
| CATT | We prefer to include Component combination 1.:UE detecting error of downlink signal for RX timing at UE side*:gNB* detecting error of uplink signal for RX timing at gNB side |
| Ericsson | Both components need to be included, with modifications.* For component 1: as explained for Question 4.3-1, (NOTE: not ) and need to be considered, which is the timing error for receiving the DL signal carrying *referenceTimeInfo-r16*.
* For component 2, ( +)/2 is needed to reflect PDC error.

Feature lead>> Please check the reply to you under question 4.3-1. I think the logic and proposal here is aligned with your proposals, you can tell that from proposal 4.3.1-1 below.  |
| Nokia, NSB | Agree and prefer Component combination 1.As we see it, the difference between Component combination 1 and combination 2 is that component combination 2 aims to reuse existing RAN4 performance requirements whereas component combination 1 is generic and not associated with performance requirements (yet).Feature lead>> Correct. Though in the end RAN4 will still need to define the Rx-Tx time difference accuracy if some new RS will be introduced. But at least from evaluation perspective, the ones defined already for PRS can be used as the reference if necessary if we go to combination 2.  |
| ZTE | We think the component combination 1 together with the errors in Q4.3-1 should be included as explained above. In addition, the Rx-Tx time difference indication error should also be included as it should be delivered from one to another for the propagation delay determination. Feature lead>> Please check the reply to you for Q4.3-1.  |
| vivo | Both component combinations are needed at this stage. The and , which refers to gNB Rx-Tx time difference measurement accuracy and UE Rx-Tx time difference measurement accuracy defined by RAN4, may not include and completely.Feature lead>> In theory these should be included in the measurment accuracy. Companies are encouraged with your RAN4 colleagues internally to save some exchange time across working groups.  |
| HW/HiSi | We prefer to include Component combination 2.The reason is that for RTT-based PDC, the gNB and the UE need to measure the Rx – Tx time difference which is similar to measurements in positioning. Thus according to the definition of the UE/gNB Rx-Tx time difference, our understanding is that the measurement accuracy already includes and . |
| LG | We prefer combination 2. It is clearer to show what are considered in each error component. |
| Qualcomm | We prefer to consider both of the combinations |
| Intel | Both options look correct, under appropriate assumptions.For further discussion in RAN1 we can prioritize Combination 1. |
| OPPO | Agree that, if and are used, and should not be accounted in PD estimation. However, our 2nd question from Question 4.3-1 still apply here: the mismatch between PD reference points for RTT measurement and PD compensation. |
| CATT2 | Key point is that and are new accuracy parameters and aren’t defined by RAN4.However, + are already defined and are used for evaluation on TA-based PDC.So we suggest using + for evaluation of RTT-based method |
| Samsung | We think both should be considered. But we can discuss whether some of value can be 0.  |

Some companies also mentioned that gNB eventually need to signal to UE about the propagation delay. Therefore, an additionally signal to indicate propagation delay cannot be avoided. The granularity of propagation delay indication will also affect the total error. As described above, this is only for gNB-based RTT PDC assuming gNB pre-compensation is not used. For UE-based RTT PDC, is not needed since no signalling needed to indicate the estimated propagation delay. Based on the discussion in previous meeting, gNB-based RTT may have RAN3 impact thus UE-based RTT seems better. However, it was concluded in previous meeting that whether to do gNB-based RTT or UE-based RTT depends on RAN2.

Though the overall equation would depend on the understanding for the above two questions, the following proposal is made as the starting point for RTT-based PDC.

**Proposal 4.3.1-1:Take one of the following two alternatives as the equation for evaluation of the overall time synchronization error for RTT-based propagation delay compensation:**

* **Alt. 1:**
	+ is to reflect the error due to report granularity of Rx-Tx time difference
	+ and reflects the measurement inaccuracy of gNB Rx-Tx time difference, and the measurement inaccuracy of UE Rx-Tx time difference, respectively.
* **Alt. 2:**
	+ is to reflect the error due to report granularity of Rx-Tx time difference

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| *Company* | *View* |
| **Feature lead**  | There are several other proposed equations from the contributions submitted in RAN1#106-e, however it looks to me that the two alternatives in the proposal here seems more reasonable. Please all double check step 1 to step 3 om section 3.1 and step 4a in section 4.3, to understand the logic of the proposal here before providing your views here.  |
| CATT | We proposes Alt.3 is as below:Feature lead>> Please check the replies to above questions, and then see if you will change your mind.  |
| Ericsson | Alt 1 |
| Nokia, NSB | Alt. 2From our understanding, the two are similar as the RxTx diff error is predominantly an Rx error. We prefer to keep the evaluation notation similar as to TA. We would also prefer not includingfollowing the same reasoning of TA-based Alt.2 equation.Feature lead>> Let’s address other issues first, and then if necessary we can add one more alternative not to include  corresponding to TA-based PDC.  |
| ZTE | This is related to the Q4.3-2 and also which alternative is selected for TA-based solution as the same equation should be used for fair comparison. Our preference is Feature lead>> Please check the replies to questions in above sections, and then see if you will change your mind. |
| vivo | We suggest the following equation:Feature lead>> Please check the replies to questions in above sections, and then see if you will change your mind. |
| HW/HiSi | We prefer Alt 1 |
| LG | Support Alt. 1 |
| Qualcomm | We support Alternative 1. |
| Intel | Alt.2, and we should also discuss the aspect of correlated / non-correlated error components for reference timing info delivery and propagation delay compensation.  |
| OPPO | Alt-1. But still, RAN1 needs to discuss what kind of RxTxDiff can work with PD compensation which relies on TimeRefereneInfo and may not take reference point at antenna connector. Feature lead>> From step 1 to step 3 in section 3.1, we can tell that there is no need to apply the same reference point (i.e. antenna connector) to receive TimeReferenceInfo, since and used there to reflect the potential error components introduced by receiving the reference time. However, for estimation of error brought by propagation delay, i.e. , the reference point can be different from the one receiving the reference time, of course in this case the errors due to receiving the referent time and estimation of propagation delay is independent.We do not support Alt-2 because we think and should not vanish. The reason is provided earlier.  |
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### 4.3.1a Third round discussion for issue 4.3-1

**Please all companies check the replies in section 4.3.1 to understand the reason to make the change**.

Based on the discussions in the above section 4.3.1, proposal 4.3.1-1 is revised as below. In general, corresponding to the alternatives for TA-based PDC, Alt.1 can be considered as the case assuming independent error components for receiving the reference time and for estimating the propagation delay.

**Revised proposal 4.3.1-1:Take the following two alternatives as the equation for evaluation of the overall time synchronization error for RTT-based propagation delay compensation:**

* **Alt. 1:**
	+ is to reflect the error due to indication granularity of Rx-Tx time difference
	+ and reflects the measurement inaccuracy of gNB Rx-Tx time difference, and the measurement inaccuracy of UE Rx-Tx time difference, respectively.
	+ ***Support:*** *Ericsson, Huawei, HiSilicon, LG, Qualcomm, OPPO, vivo*
* **Alt. 2:**
	+ is to reflect the error due to indication granularity of Rx-Tx time difference
	+ *[Note: Alt.2 assumes that the time of PD estimation is close to the time of PD compensation, in which case the DL frame timing error and BS transmit timing error for propagation delay estimation is correlated to that for the transmission of RRC signaling carrying the reference time clock]*
	+ ***Support:*** *Nokia, NSB, Intel, CATT, ZTE (?), Samsung*

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| *Company* | *View* |
| Nokia, NSB | We agree with revised proposal for Alt.2.Due to limit WI time, we think there is a risk creating a dependency on requirements non yet defined in RAN4 for the evaluation of time sync error, whereas we have already agreed values for the error components of and .Please, also check a typo on the definition of indication error * + is to reflect the error due to report granularity of Rx-Tx time difference

Feature lead>> Thanks. Update accordingly on the typo |
| Vivo  | If companies think that transmit timing error introduced due to UE internal implementation needn’t be considered for . We can accept Alt 1. |
| CATT | We agree with Alt.2 with Nokia’s modification.Key point is that and are new accuracy parameters and aren’t defined by RAN4.However, + are already defined and are used for evaluation on TA-based PDC.So considering limited time of this project, we suggest using + for the error evaluation of RTT-based method. |
| Intel | Agree to either go with both, or to down-select now to Alt.2 |
| ZTE | We can support Alt.1 only if the measurement inaccuracy of gNB Rx-Tx time difference includes the BS transmitting time error and BS reception time error and the UE Rx-Tx time difference includes the UE transmitting time error and UE reception time error.Response to FL for the Q4.3-1:

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| Feature lead>> According to the definition in RAN4 spec, the reference point for TUE-RX measurement shall be the Rx antenna connector of the UE and the reference point for TUE-TX measurement shall be the Tx antenna connector of the UE. Therefore, it doesn't matter whether there is any error for the uplink transmit timing compared to the DL frame timing. Note that we define for TA-based PDC (i.e.) would also include the potential error of DL frame timing error as replied by RAN4. As to the potential transmit timing error introduced due to UE internal implementation, e.g. time interval between baseband and antenna connector, it is expected that these kind of errors will be included in the Rx-Tx time difference accuracy. |

We still don’t understand why does not matter in this case just because in the definition the reference point is the antenna connector. The definition of the Rx-Tx time difference is the reception time of a signal and the transmitting time of another signal. If only the reception time error is considered, it means there is no error for the transmitting time of the signal at the antenna connector. That is to say, the UE can know the transmitting of the signal at the antenna connector exactly. This is impossible, since the error exists anyway, which is exactly . It represent the error between the actual transmitting time and the time that the UE wants to transmit the signal in our understanding. |
| Samsung | We can live with Alt 2 with modification from Nokia. |
| OPPO(Fri Aug 20) | Even though we support Alt-1 formula, we see fundamental difference between companies on how to interpret the timing measurement reference point in RTT-based PDC error analysis. This mismatch of understanding among companies can be traced back all the way to the formula given in section 3.1:  (1)which can be equivalently reformulated as  (2)The left side of (2) is “the one-way propagation delay from gNB baseband to UE baseband”, since ReferenceTimeInfo timing is not taken at antenna connector (according to 38.331); in contrast, the right side of (2), according to FL and quite some proponents of RTT\_based PDC, is “the one-way propagation delay from gNB antenna connector to UE antenna connector”, then the question is how the values on two sides of (2) can be equal, since antenna-to-antenna PD should be strictly less than baseband-to-baseband PD. We believe all the measures on right side of (2) should take reference not at antenna connector but at the reference point with which ReferenceTimeInfo is treated, and this also means variables in Alt-1 should take reference not at antenna connector. Based on this reasoning, the comment from ZTE looks valid. We suggest to revise the analysis for RTT-based PDC from beginning before stepping further on RTT-based PDC, by clarifying the definition of every timing variable, and avoiding ending up with two formula. Feature lead>> Thanks for your further comments. Note that it is not all right side of (2) take reference at antenna connector, e.g. the following two highlight in red is still the same as what we defined for TA-based PDC. In addition, as I replied to ZTE, the potential transmit timing error introduced due to UE internal implementation, e.g. time interval between baseband and antenna connector, it is expected that these kind of errors will be included in the Rx-Tx time difference accuracy. By the way, you could tell that in order to help people achieve common understanding, I have been trying to set questions/discussion step by step in the past meetings and this meeting, however still different views among different companies. Due to the limited time for us, the possible way for us to move forward is to take both alternatives as the working assumption similar as TA-based PDC instead of arguing which one is better, since I expect continue this kind of discussion will turn out only waste of all our time with nothing achieved. If any better idea on how to move forward, happy to hear also.  |
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**Issue 4.3-2: What reference signal to use for estimating Rx-Tx time difference for time synchronization?**

In RAN1#104bis-e meeting, the following is agreed with two FFS.

Agreement:

Existing DL reference signal(s) are used for Rx – Tx time difference estimation at UE side for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.

* FFS whether PRS can be used for UE Rx – Tx time difference estimation or not
* FFS which DL reference signal(s) to be used if/when PRS is not used

### First round & Second round discussion for issue 4.3-2

**Original proposals not changed based on first round email discussion yet. Companies are encouraged to check the replies and provide your further comments if any.**

In RAN1#106-e meeting, Nokia (R1-2106638) and Huawei (R1-2107678) consider DL CSI-RS for tracking, and Samsung (R1-2106883) consider CSI-RS and SSB. It seems DL CSI-RS for tracking is a promising candidate. Therefore, I made the following tentative proposal for further discussion.

**Proposal 4.3.2-1:If RTT-based propagation delay compensation is supported, CSI-RS for tracking (TRS) is used for Rx – Tx time difference estimation at UE side, if PRS is not available.**

**Proposal 4.3.2-1-x:If RTT-based propagation delay compensation is supported, PRS is used for Rx – Tx time difference estimation at UE side, if PRS is available.**

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| *Company* | *View* |
| CATT | We want to clarify how UE estimates Rx – Tx time difference estimation at UE side based on only CSI-RS.Feature lead>> UE will do the measurement based on the TRS, and the corresponding measurement accuracy will be further discussed in RAN4 as the proposal in section 4.3.3. |
| Ericsson | While it is technically possible to use CSI-RS to achieve PDC accuracy similar to that of PRS, we prefer to prioritize PRS as DL signal, since RAN4 has conducted extensive investigation of UE *RxTxTimeDiff* accuracy using PRS. These can be easily inherited for time sync purpose. If RAN1 uses CSI-RS instead, then substantial investigation work is needed in both RAN1 and RAN4. This may not be feasible given the limited meeting time left.Feature lead>> The problem is that the support of PRS depends on the support of some positioning mechanism. Couple the support of RTT-based PDC with the support of some positioning procedure is not good. In addition, of course if PRS is available, it can be used. I can make another proposal for PRS also just to make it clearer.  |
| Nokia, NSB | Support.According our evaluations provided in our contribution, with the use of CSI-RS for tracking (TRS) to determine the DL timing, the DL RX error is low enough to achieve the strictest requirement from control-to-control even in multipath channel and using a DL bandwidth of 10MHz. Therefore, we support the proposal to use CSI-RS for Rx-Tx if PRS is not available or needed (up to gNB to configure the RS).Feature lead>> Agree. Thanks for the evaluation also.  |
| ZTE | We wonder if UL signal/RS is also needed for Rx-Tx time difference estimation at UE side. According to the definition above, it is understood the UL signal/RS is transmitted in uplink subframe #j.Feature lead>> According to the current RAN4 definition for UE Rx-Tx time difference measurement, only DL RS is considered. |
| vivo | Does it mean that a new procedure would be introduced for propagation delay estimation based on CSI-RS for Rx – Tx time difference estimation at UE side? The accuracy requirement based on CSI-RS for Rx – Tx time difference estimation needs evaluation, e.g. bandwidth, density period of CSI-RS.Feature lead>> Yes. However, it is expected that the work on PRS can be able to provide some reference which can make the work in RAN4 easier.  |
| Hw/HiSi | We are fine with the proposal. |
| Qualcomm | We are OK with the proposal |
| Intel | We support proposal 4.3.2-1, but not sure about 4.3.2-1-x. Usage of PRS may complicate the spec and UE implementation. PRS configurations are provided by LPP, and PDC procedure is targeted to be fully managed by gNB w/o relying on LPP.Feature lead>> Agree we cannot couple PDC with positioning procedure. The intention here is to say that if UE anyway already has the capability to support PRS, then this PRS can be used for PDC also, in which case the PRS configuration can be from gNB instead of LPP.  |
| OPPO | For **Proposal 4.3.2-1**, we think the key question is whether RAN4 would give corresponding RAN4 performance requirement for CSI-RS based RTT measurement. From RAN1 point of view, if there is no RAN4 performance requirement, it is then totally up to UE implementation whether to add CSI-RS timing monitoring to the whole RTT-based PDC profile. Given the current RAN4 schedule and work load, we have a concern whether RAN4 could give the corresponding numbers for CSI-RS. Feature lead>> In my understanding, RAN4 needs to define the corresponding measure accuracy, to ensure the performance, just similar as what done for positioning. RAN1 needs to let RAN4 know it as early as possible, then RAN4 can start the work early. By the way, the deadline for RAN4 is later than that in RAN1. For **Proposal 4.3.2-1-x,** is PRS used for PDC purpose still belonging to positioning protocol? Or this PRS is just a “new” signal outside positioning framework but just sharing the same signal structure and the same signal name with positioning RS? If it is a new signal, we would like to ask for a clarification whether the RAN4 requirement can still apply. Feature lead>> The intention here is to say that if UE anyway already has the capability to support PRS (e.g. for UEs supporting positioning), then this PRS can be used for PDC also, in which case the PRS configuration can be from gNB instead of LPP. And we need to ensure separate procedure for PDC from positioning procedure.  |
| Samsung | We think we shall not require UE to mandatory support PRS for PDC. But we are fine to make it optional.  |

In addition, the UL RS for Rx-Tx time difference estimation at the gNB side needs to be discussed and defined also. In TS 38.215, gNB Rx-Rx time difference is defined based on SRS, it is straightforward to reuse the current mechanisms as much as possible. Therefore, I made the following tentative proposal for further discussion.

**Proposal 4.3.2-2:SRS is used** **for Rx – Tx time difference estimation at gNB side for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.**

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| *Company* | *View* |
| CATT | We want to clarify how gNB estimates Rx – Tx time difference estimation by only SRS at gNB side.Feature lead>> gNB will do the measurement based on the SRS, and the corresponding measurement accuracy will be further discussed in RAN4. It is expected that the current measurement accuracy based on SRS defined for positioning can be reused as much as possible.  |
| Ericsson | Support. We agree that the existing gNB RxTxTimeDiff accuracy defined for SRS for positioning purpose can be easily reused for time sync purpose. |
| Nokia, NSB | Support |
| ZTE | Similar as the last question, we wonder whether DL signal/RS is also needed for Rx-Tx time difference estimation at gNB side. According to the definition above, it is understood the DL signal/RS is transmitted in downlink subframe #j.Feature lead>> According to the current RAN4 definition for gNB Rx-Tx time difference measurement, only SRS is considered.  |
| vivo | Support. |
| HW/HiSi | Support. |
| Qualcomm | Support |
| Intel | Support |
| OPPO | In principle we are fine, given RAN4 is already working on this for positioning purpose. But we want to highlight that the SRS mentioned should be existing SRS. With this understanding, what if the same SRS is used for TA-based PDC and implicit PDC? Would assumption of 100ns UL-Rx error at gNB be modified (to be smaller) for TA-based PDC and implicit PDC? Feature lead>> Yes existing SRS will be used. Actually the agreed value for the current UL-Rx error at gNB for TA-based PDC is given based on evaluation on SRS already.  |
| Samsung | Support |

### 4.3.2a Third round discussion for issue 4.3-2

**Please all companies check the replies in section 4.3.2 to understand the reason to make the change**.

**Revised Proposal 4.3.2-1:If RTT-based propagation delay compensation is supported, CSI-RS for tracking (TRS) is used for Rx – Tx time difference estimation at UE side, if PRS is not configured for the UE.**

* + **Support*:*** *Nokia, NSB, Huawei, HiSilicon, Qualcomm, Intel, Samsung, vivo, CATT*

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| *Company* | *View* |
| Feature lead | @ Ericsson @ ZTE @ OPPOPlease check my replies to your comments in section 4.3.2 above and provide your further thinking if any.  |
| Nokia, NSB | **Support in principle**, with the following update (sorry for not noticing this earlier): it is unclear to us, what it means to have “*PRS available*”. To be more precise we think it should be depending on if the UE is configured with PRS, i.e. **If RTT-based propagation delay compensation is supported, CSI-RS for tracking (TRS) is used for Rx – Tx time difference estimation at UE side, if PRS is not configured for the UE ~~available~~.** Feature lead>> “available” originally includes either UE doesn’t have the capability to support PRS or even has the capability but not configured. Anyway I think ok to update according to your suggestion because that is the final case.  |
| vivo | We can support the Revised Proposal 4.3.2-1. |
| CATT | For the sake of the progress, we are fine with FL proposal. |
| Intel | Still support |
| ZTE | Maybe our question is not clear in the first round.The Rx-Tx time difference at UE side is defined as the receiving time of the downlink subframe #i and the transmitting time of the uplink subframe #j. Actually, the is no UL RS mentioned. Our question is about the uplink subframe. Is it up to UE implementation to select which uplink subframe is for the Rx-Tx time difference determination?Feature lead>> From the UE side, UE only needs to do the measurement based on DL RS. Of course, at the gNB side what UL RS to use matters, as the proposal below. As to whether we need to pair the DL RS and UL RS, I think we can further discuss.  |
| Samsung | Clarification question: does this mean, UE has to support PRS based PDC? If no, we are fine, otherwise, we suggest to delete “if not configured. ”,.**If RTT-based propagation delay compensation is supported, CSI-RS for tracking (TRS) is used for Rx – Tx time difference estimation at UE side, ~~if PRS is not configured for the UE or not supported by UE.~~**Feature lead>> No, it doesn’t mean UE has to support PRS based PDC. Only for UEs supporting positioning and thus supporting PRS, can do the PDC based on PRS.  |
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**Proposal 4.3.2-2:SRS is used for Rx – Tx time difference estimation at gNB side for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.**

* + **Support*:*** *Ericsson, Nokia, NSB, vivo, Huawei, HiSilicon, Qualcomm, Intel, Samsung, CATT*

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| *Company* | *View* |
| Feature lead | @ ZTE @ OPPOPlease check my replies to your comments in section 4.3.2 above and provide your further thinking if any. |
| Nokia, NSB | Support. |
| vivo | Support. |
| CATT | For the sake of the progress, we are fine with FL proposal.  |
| Intel | Still support |
| ZTE | Similar as above, how about the downlink subframe in this case?Feature lead>> Please check the replies above.  |
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**Revised Proposal 4.3.2-1-x:If RTT-based propagation delay compensation is supported, PRS is used for Rx – Tx time difference estimation at UE side, if PRS is configured for the UE.**

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| *Company* | *View* |
| Feature lead | The intention here is to say that if UE anyway already has the capability to support PRS (i.e. for UEs supporting positioning), then this PRS can be used for PDC also, in which case the PRS configuration can be from gNB instead of LPP. Note that here is not to couple PDC with positioning procedure.  |
| Nokia, NSB | **Support in principle**, with the following update (sorry for not noticing this earlier): it is unclear to us, what it means to have “*PRS available*”. To be more precise we think it should be depending on if the UE is configured with PRS, i.e. **If RTT-based propagation delay compensation is supported, PRS is used for Rx – Tx time difference estimation at UE side, if PRS is configured for the UE ~~available~~.**  |
| vivo | Support.  |
| CATT | For the sake of the progress, we are fine with FL proposal.  |
| Intel | At this point it looks like an optimization since it assumes a system with positioning capability + enhanced timing synchronization capability, and a UE with positioning capability + enhanced timing sync capability.As showed by analysis by some companies, usage if CSI-RS/TRS provides sufficient accuracy for UE measurements.Note, that PRS in many cases requires measurement gaps since a UE could not do measurements together with regular U-plane operations.We would also like to see how PRS configurations and measurement gaps provides by LPP interact with the RAN managed RTT measurements procedure, before agreeing on this proposal.In summary, we think more analysis is needed to decide whether to agree on this proposal. |
| ZTE | If RTT-based solution is supported, CSI-RS is our preference first to avoid the much RAN1 work. |
| Samsung | We share the views from Intel. But for the sake of progress, We can live with PRS as optional feature.**If RTT-based propagation delay compensation is supported, PRS can be ~~is~~ used for Rx – Tx time difference estimation at UE side as optional feature~~, if PRS is configured for the UE.~~**  |
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**Outcome of Friday GTW session for issue 4.3-2**

**Agreement**

SRS can be used for Rx – Tx time difference estimation at gNB side for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.

**Agreement**

If RTT-based propagation delay compensation is supported,

* CSI-RS for tracking (TRS) can be used for Rx – Tx time difference estimation at UE side, if PRS is not configured for the UE.

PRS can be used for Rx – Tx time difference estimation at UE side, if PRS is configured for the UE.

**Issue 4.3-3: general procedures related to RTT-based PDC**

Nokia (R1-2106638) proposes the Rx-Tx configuration and Rx-Tx measurement report as below.

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| Nokia (R1-2106638)Proposal 8: The Rx-Tx configuration should contain:* At least one DL RS configuration (FFS which configurations to support)
* At least one UL RS configuration (FFS which configurations to support)
* A relation between DL RS and UL RS (FFS whether to reuse the existing definition from 38.215)

Proposal 9: The Rx-Tx measurement report provided from the gNB to the UE should include at least:* Rx-Tx measurement at fixed granularity (FFS which granularity)
* SRS-Resource-ID
 |

### First round &Second round discussion for issue 4.3-3

Based on the description for issue 4.3-2 above, I made the following tentative proposals for further discussion.

**Proposal 4.3.3-1:Support the following Rx-Tx configurations for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.**

* **At least one CSI-RS for tracking (TRS) configuration for Rx – Tx time difference estimation at UE side**
* **At least one SRS configuration for Rx – Tx time difference estimation at gNB side**

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| *Company* | *View* |
| CATT | See our comment on Proposal 4.3.2-1 and Proposal 4.3.2-2 Feature lead>> Please check replies above for Proposal 4.3.2-1 and Proposal 4.3.2-2.  |
| Ericsson | We are fine with the intention of the proposal. However, preferably PRS should be reused as the DL RS, not CSI-RS.Feature lead>> Please check replies above in section 4.3.2.  |
| Nokia, NSB | Support |
| ZTE | Does it mean a dediciated TRS/SRS configured for Rx-Tx time difference estimation for propagation delay compensation? Or TRS and SRS should be configured for a connected UE anyway and it is up to the UE implementation to select one of them for measurement.Feature lead>> We need some dedicated configuration, since it will have impact on the measurement accuracy. It seems difficult to leave it to implementation.  |
| Vivo | See our comment onProposal 4.3.2-1 Feature lead>> Please check replies above in section 4.3.2. |
| HW/HiSi | Support |
| Qualcomm | Agree |
| Intel | While we agree with the proposal, we want to understand more whether we may need more than one configuration for DL RS and UL RSFeature lead>> That’s up to further discussion.  |
| OPPO | First, this proposal depends on the outcome of proposals in issue 4.3.2. Secondly, is it the intention to make UE and gNB to use the configured RS only but not to allow them adding other RS signals (that is not configured for RTT difference estimation) to the timing detection implementation? If yes, does it mean the RTT to be measured has to be between one configured DL RS and one configured UL RS? Feature lead>> We can further discuss whether any pairing of the DL RS and UL RS needed. Thirdly, try to understand “at least one”: if there are two DL RS configurations for RTT estimation, what is the difference between the two RTT estimations respectively obtained from each DL RS configuration? Feature lead>> We can further discuss whether more than one is necessary, that is why at least is used here.  |
| Samsung | Support |

**Proposal 4.3.3-2:If RTT-based propagation delay compensation is supported and performed at the UE side, the Rx-Tx measurement report provided from the gNB to the UE should include at least:**

* **Rx-Tx measurement at fixed granularity (FFS which granularity)**
* **SRS-Resource-ID**

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| *Company* | *View* |
| CATT | From our perspective, DL signal ID is also needed.Feature lead>> This is only for gNB Rx-Tx time different, thus no need to involve DL signal ID.  |
| Ericsson | This question depends on which entity performs PDC. The proposal above assumes that UE performs PDC, but RAN1 has agreed that it’s up to RAN2 to decide which entity to perform PDC.Feature lead>> Right. I updated the proposal to clarify. In general, it seems companies feel that UE based compensation is better due to no impact at RAN3.  |
| Nokia, NSB | Support |
| ZTE | We believe the DL RS ID should also be needed to indicate the RS for Rx-Tx measurement as pointed out by CATT. In addition, if the DL RS or the UL RS is periodic, we think the specific DL RS/UL RS that the network measures should also be indicated. Otherwise, the UE and the network may measure the different DL/UL RS, which leads to the obtained propagation delay is not as accurate as what we analyze here. Feature lead>> This is only for gNB Rx-Tx time different, thus no need to involve DL signal ID. |
| Vivo | Support |
| Qualcomm | Support |
| Intel | We are not sure if SRS-Resource-ID is always required. In many cases, the reported time difference can be directly associated with a prior SRS transmission, when SRS for PDC is explicitly provided.Feature lead>> Here the intention is to say if more than one SRS resource is configured for gNB Rx-Tx time difference measurement, then gNB can indicate the SRS-Resource-ID used. However, since it is still not clear whether more than one SRS resource will be used, we can change it to FFS right now.  |
| OPPO | Not really. Not sure why SRS-Resource-ID should be included, unless different SRS resource ID would eventually result in different SRS Tx timing in UE or different SRS RX timing in gNB. But is this the case? Feature lead>> Here the intention is to say if more than one SRS resource is configured for gNB Rx-Tx time difference measurement, then gNB can indicate the SRS-Resource-ID used. However, since it is still not clear whether more than one SRS resource will be used, we can change it to FFS right now. |

In addition, it is expected that RAN4 needs to define the Rx-Tx time difference measurement accuracy for DL CSI-RS used for Rx-Tx time difference measurement at the UE side. RAN4 is discussing the measurement accuracy for PRS with the current outcome as shown in the following table.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 10.1.25.2-1: UE Rx-Tx time difference measurement accuracy in FR1 in AWGN

|  |  |
| --- | --- |
| Accuracy | Conditions |
| PRS Ês/Iot | Minimum PRS bandwidth | PRS SCS | PRS resource repetition Note 3 |  | IoNote 4 range |
| NR operating band groupsNote 2 | MinimumIoNote 1 | MaximumIo |
| TcNote 5 | dB | RB | kHz |  |  | dBm / SCSPRS | dBm/BW |
| **SCSPRS=15 kHz** | **SCSPRS=30 kHz** | **SCSPRS=60 kHz** |
| ± [78+δ] | -3 | ≥[24] | 15 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [59+δ] | ≥[52] | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [30+δ] | >[104] | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| TBD |  | ≥[24] | 30 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [30+δ] |  | ≥[48] |  |  ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [15+δ] |  | ≥[132] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [29+δ] | ≥[24] | 60 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [15+δ] |  | ≥ [64] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [7+δ] |  | ≥ [132] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [101+δ] | -13 | ≥[24] | 15 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [75+δ] | ≥[52] | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [39+δ] | >[104] | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| TBD |  | ≥[24] | 30 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [37+δ] |  | ≥[48] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [16+δ] |  | ≥[132] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [36+δ] | ≥[24] | 60 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [16+δ] |  | ≥ [64] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [8+δ] |  | ≥ [132] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| NOTE 1: This minimum Io condition is expressed as the average Io per RE over all REs in an OFDM symbol.NOTE 2: NR operating band groups are as defined in Section 3.5.NOTE 3: are configured by higher layer parameter *dl-PRS-ResourceRepetitionFactor, dl-PRS-NumSymbols and dl-PRS-CombSizeN*defined in TS 37.355 [34].NOTE 4: The Io is defined in PRS slots. The same Io range applies to PRS and non-PRS symbols. Io levels are different in PRS and non-PRS symbols within the same slot.NOTE 5: Tc is the basic timing unit defined in TS 38.211 [6]. |

Table 10.1.25.2-2: UE Rx-Tx time difference measurement accuracy in FR1 in fading

|  |  |
| --- | --- |
| Accuracy | Conditions |
| PRS Ês/Iot | Minimum PRS bandwidth | PRS SCS | PRS resource repetition Note 3 |  | IoNote 4 range |
| NR operating band groupsNote 2 | MinimumIoNote 1 | MaximumIo |
| TcNote 5 | dB | RB | kHz |  |  | dBm / SCSPRS | dBm/BW |
| **SCSPRS=15 kHz** | **SCSPRS=30 kHz** | **SCSPRS=60 kHz** |
| ± [137+δ] | -3 | ≥[24] | 15 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [96+δ] | ≥[52] | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [62+δ] | >[104] | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| TBD |  | ≥[24] | 30 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [68+δ] |  | ≥[48] |  |  ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [44+δ] |  | ≥[132] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [59+δ] | ≥[24] | 60 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [42+δ] |  | ≥ [64] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [36+δ] |  | ≥ [132] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [180+δ] | -13 | ≥[24] | 15 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [98+δ] | ≥[52] | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [68+δ] | >[104] | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| TBD |  | ≥[24] | 30 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [85+δ] |  | ≥[48] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [44+δ] |  | ≥[132] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [139+δ] | ≥[24] | 60 | ≥[4] | TBD | TBD | TBD | TBD | TBD |
| ± [66+δ] |  | ≥ [64] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| ± [30+δ] |  | ≥ [132] |  | ≥[1] | TBD | TBD | TBD | TBD | TBD |
| NOTE 1: This minimum Io condition is expressed as the average Io per RE over all REs in an OFDM symbol.NOTE 2: NR operating band groups are as defined in Section 3.5.NOTE 3: are configured by higher layer parameter *dl-PRS-ResourceRepetitionFactor, dl-PRS-NumSymbols and dl-PRS-CombSizeN*defined in TS 37.355 [34].NOTE 4: The Io is defined in PRS slots. The same Io range applies to PRS and non-PRS symbols. Io levels are different in PRS and non-PRS symbols within the same slot.NOTE 5: Tc is the basic timing unit defined in TS 38.211 [6]. |

Table 13.2.2.2-1: gNB Rx-Tx time difference absolute accuracy in FR1 for gNB type 1-C, 1-H and 1-O

|  |  |  |  |
| --- | --- | --- | --- |
| **Accuracy** | **SRS Ês/Iot** | **SCS** | **SRS bandwidth range** |
| **Unit: Tc** | **Unit: dB** | **Unit: kHz** | **Unit: RB** |
| [63] | ≥ -13 | 15 |  44 ≤ BW ≤ 84 |
| [31] |  88 ≤ BW ≤ 168 |
| [15] | 176 ≤ BW |
| [117] | ≥ +3 | 24 ≤ BW ≤ 40 |
| [60] |  44 ≤ BW ≤ 84 |
| [31] |  88 ≤ BW ≤ 168 |
| [15] | 176 ≤ BW |
| [37] | ≥ -13 | 30 |  48 ≤ BW ≤ 84 |
| [15] |  88 ≤ BW ≤ 168 |
| [8] | 176 ≤ BW |
| [31] | ≥ +3 |  48 ≤ BW ≤ 84 |
| [15] |  88 ≤ BW ≤ 168 |
| [8] | 176 ≤ BW |
| [19] | ≥ -13 | 60 |  48 ≤ BW ≤ 84 |
| [8] |  88 ≤ BW  |
| [15] | ≥ +3 |  48 ≤ BW ≤ 84 |
| [8] |  88 ≤ BW  |

Table 13.2.2.2-2: gNB Rx-Tx time difference absolute accuracy in FR2 for gNB type 2-O

|  |  |  |  |
| --- | --- | --- | --- |
| **Accuracy** | **SRS Ês/Iot** | **SCS** | **SRS bandwidth range** |
| **Unit: Tc** | **Unit: dB** | **Unit: kHz** | **Unit: RB** |
| [8] | ≥ -13 | 60 |  132 ≤ BW ≤ 168 |
| [6] | 176 ≤ BW |
| [8] | ≥ +3 | 132 ≤ BW ≤ 168 |
| [6] | 176 ≤ BW |
| [19] | ≥ -13 | 120 |  32 ≤ BW ≤ 40 |
| [8] |  44 ≤ BW ≤ 84 |
| [6] | 88 ≤ BW |
| [15] | ≥ +3 |  32 ≤ BW ≤ 40 |
| [8] |  44 ≤ BW ≤ 84 |
| [6] | 88 ≤ BW |

 |

Similar definition can be considered. For SRS, maybe the current RAN4 definition can be reused, however it is up to RAN4. I made the following tentative proposals for further discussion.

**Proposal 4.3.3-3: Send LS to RAN4 to ask for defining the following for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.**

* **UE Rx-Tx time difference measurement accuracy based on CSI-RS**
* **gNB Rx-Tx time difference absolute accuracy based on SRS**

|  |  |
| --- | --- |
| *Company* | *View* |
| Ericsson | Do not support. RAN1 should agree to support RTT based PDC or not first. RAN1 should not ask RAN4 to do any work without knowing if the work is needed or not. Also: We suggest to reuse PRS For UE RxTxTimeDiff, so that work done in RAN1/RAN4 for positioning purpose can be simply reused. If using CSI-RS, RAN1 and RAN4 need to investigate UE RxTxTimeDiff accuracy based on CSI-RS.Feature lead>> On whether to reuse PRS, please check replies above. Sure the LS will be sent only we agree to support RTT-based propagation delay. The problem right now is that still difficult to agree on the equation to evaluate the overall synchronization error for RTT-based PDC as shown in section 4.3.1, also seems there is no sufficient evaluation in companies papers also. Without the evaluation, it seems difficult to achieve consensus to support RTT-based PDC right now.  |
| Nokia, NSB | **Support in principle**We think we should also capture the bandwidth options to be supported. Our analysis has shown that the following DL RX errors are present.Table 1: 90%ile DL timing error in nanoseconds of CSI-RS for tracking (FR1, 15kHz SCS, -6dB SNR)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DL #RBs** | **DL BW** | **TDL-A** | **TDL-B** | **TDL-C** |
| **25** | **5 MHz** | 65.1 | 97.7 | 227.9 |
| **52** | **10 MHz** | 32.6 | 65.1 | 97.7 |
| **104** | **20 MHz** | 32.6 | 48.8 | 73.2 |
| **268** | **50 MHz** | 20.4 | 32.6 | 40.7 |

**Therefore, to be more specific, we may ask RAN4 for defining the requirements only for one Ês/Iot (as only serving cell may be considered), for 15KHz and 30 KHz subcarrier spacing, and for up to 10 MHz bandwidth.**Feature lead>> Agree. The problem right now is that not many companies provide evaluation yet, maybe let’s try to get the TRS and RTT-based PDC agreed first.  |
| ZTE | Is the intention to let RAN4 define the new requirement to fulfill the requirement for RTT-based solution? If yes, we think it is a bit early to discuss this issue since we haven’t decided to support RTT-based solution yet. Feature lead>> The problem is not much time left especially considering RAN4 will only have 1 more meeting this year.  |
| vivo | For using PRS, some parameters for the evaluation of RTT-based PDC should be determined firstly, at least including* + - for 30kHz and δ value for 15kHz
		- for fading channel

Feature lead>> The LS is to address your comment here actually, since these value need RAN4 work.  |
| HW/HiSi | Support the proposal |
| LG | Support in principle. In order to support RTT-based PDC with CSI-RS, it would be necessary to clarify whether error budget satisfies with CSI-RS.  |
| Qualcomm | Support the proposal |
| OPPO | No. What proposed is what RAN1 should discuss after agreeing on RTT-based PDC together with what kind of DL RS being used.  |
| Samsung | We can discuss this proposal later. Agree with Ericsson that we’d better to agree on which solution, or both solutions we will support, then ask RAN 4 to work on it.  |

### 4.3.3a Third round discussion for issue 4.3-3

**Proposal 4.3.3-1:Support the following Rx-Tx configurations for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.**

* **At least one CSI-RS for tracking (TRS) configuration for Rx – Tx time difference estimation at UE side**
* **At least one SRS configuration for Rx – Tx time difference estimation at gNB side**
	+ **Support*:*** *Nokia, NSB, Huawei, HiSilicon, Qualcomm, Intel, Samsung, vivo, CATT*

|  |  |
| --- | --- |
| *Company* | *View* |
| Feature lead | @ CATT @ Ericsson @ ZTE @ vivo @ OPPOPlease check my replies to your comments in section 4.3.3 above and provide your further thinking if any.  |
| Nokia, NSB | Support. |
| vivo | Support. |
| CATT | For the sake of the progress, we are fine with FL proposal.  |
| Intel | Agree |
| ZTE | This question may be clear if we can make a consensus on the above proposals. |
| OPPO | Not support. We do not think it is necessary to mandate UE to be configured with specific type of signal. * For CSI-RS, according to earlier RAN1 agreement, PRS may or may not be configured for RTT measurement purpose, then why does CSI-RS for the same purpose have to be configured?
* For SRS, for the following three types of SRS, why does UE have to be configured with the 1st one for RTT measurement? Could UE just use the 2nd one and/or 3rd one in case the 1st is not configured?
	+ SRS for RTT timing difference (created in this agenda);
	+ SRS for multi-RTT based positioning (created in Rel-16 positioning)
	+ General purpose SRS
 |
|  |  |

**Revised Proposal 4.3.3-2:If RTT-based propagation delay compensation is supported and performed at the UE side, the Rx-Tx measurement report provided from the gNB to the UE should include at least:**

* **Rx-Tx measurement at fixed granularity (FFS which granularity)**
* **FFS whether to include SRS-Resource-ID**
	+ **Support*:*** *Nokia, NSB, vivo, Huawei, HiSilicon, Qualcomm, CATT, Intel*

|  |  |
| --- | --- |
| *Company* | *View* |
| Feature lead | @ CATT @ Ericsson @ ZTE @ OPPO @ IntelPlease check my replies to your comments in section 4.3.3 above and provide your further thinking if any.  |
| Nokia, NSB | Support  |
| vivo | Support |
| CATT | Support |
| Intel | Agree, since SRS Resource-ID is under FFS |
| Qualcomm | support |
| OPPO | For “**FFS which granularity**”, it is a tradition (in both positioning and Rel-16 IAB) that such RTT indication granularity (along with RTT value range) was determined in RAN4, not RAN1.  |

### 4th round discussion for RTT-based PDC

In RAN2#115e, RAN2 achieved the following agreements:

**Agreements**

1. RAN2 assumes that gNB can perform pre-compensation.  RAN2 agrees to introduce signalling to enable/disable UE-side PDC.
2. The gNB can enable/disable UE-side PDC via unicast-RRC signalling for Rel-17
3. RAN2 shall wait for RAN1 to decide the measurement framework for RTT based PDC method and does not preclude UE-side PDC or gNB based pre-compensation at this point.  RAN2 is expecting guidance from RAN1 on what is needed.
4. UE Assistance information from the UE which could for example be used by gNB to activate PDC is not supported
5. Implicit activation of UE-side PDC when a pre-configured threshold is met is not supported
6. UE-based trigger for TA update or RACH procedure for PDC are deprioritized for Release 17

From the above point 3 highlight in yellow, we can tell that RAN2 is waiting for the measurement framework for RTT based PDC from RAN1. Therefore, I think it is worthwhile to send LS to RAN2 to inform them the agreements we achieved for RTT-based PDC.

**Proposal 4.3.4-1:Send an LS to RAN2 with the content including:**

* **Agreements for RTT-based PDC achieved in RAN1#106-e**
* **Conclusion achieved in RAN1#104b-e:**
	+ **Leave it to RAN2 to decide whether to support UE based compensation and/or gNB based compensation for any propagation delay compensation method RAN1 may adopt for Rel-17, if applicable.**

|  |  |
| --- | --- |
| *Company* | *View* |
| Feature lead | Note that for TA-based PDC, since we will send LS to RAN4 based on the agreement achieved on Friday GTW and we will copy to RAN2, thus the key agreements for TA-based PDC can be informed to RAN2 there.  |
| ZTE | We are not sure whether this LS is needed since we don’t think we have valuable agreements for RTT-based PDC that RAN2 needs to take into account. We have not agreed to support RTT-based PDC yet.For the conclusion achieved in RAN1#104b-e, we think it is not needed since RAN2 has already agreed that gNB can perform pre-compensation . |
| OPPO | Similar comments as from ZTE. What RAN1 agreed so far for RTT-based PDC are just a set of hypothesis, not something that can be named “guidance”. RAN2 can learn these information without any LS. For conclusion from RAN1 #104bis-e, we made the online comment in RAN1 #104b-e session to suggest a LS to RAN2, but at that time got the response the LS is not necessary. It seems good to keep the consistency.  |
| Nokia/NSB | Support. Although we have not agreed to support RTT-based operation yet (neither we have agreed any TA based enhancements), it would be good to inform RAN2 about the RAN1 progress incl. any agreements we have made so far or are still able to make during RAN1#106-e.  |
| vivo | We share the similar view with ZTE/OPPO. We have not agreed to support RTT-based PDC yet. All agreements on RTT-based PDC achieved in this meeting are based on a premise, i.e., if RTT-based propagation delay compensation is supported. I’m not sure whether it is meaningful to send the LS.  |
| HW/HiSi | Support. Agree with Nokia. |
| Samsung | We also don’t think there is a need to send LS to RAN 2 now considering not much progress were made for RTT based method, and RAN 1 still discussion on TA based method. |

## Implicit propagation delay compensation

OPPO (R1-2107276) proposes an implicit PDC method as below:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *OPPO R1-2107276*Figure 1 Implicit PDC timing diagram with signalling flow (Option-1)The principle of implicit PDC is to obtain an adjusted clock value () on UE side, at any time t, aswhere * is the clock time on UE side that is made synchronized to the clock inside gNB.
* is the nominal clock time locally running inside UE at time t. This clock is not modifiable by procedures such as TA or PDC.
* is the most recent clock error estimation made before time t, where, as shown in Figure 1,
	+ and are respectively the gNB clock time associated with the reception of a PUSCH and UE nominal clock time (i.e., running on ) associated with the transmission of the same PUSCH, where the PUSCH carries a message information relating to . is also delivered back to UE via RRC signaling.
	+ and are respectively the UE nominal clock time (i.e., running on ) associated with the reception of a PDSCH and gNB clock time associated with the transmission of the same PDSCH, where the PDSCH carries a message information relating to .

The clock synchronization error of implicit PDC (Option-1) is simply the error of , which is given byAssume ReferenceTimeInfo RRC IE is reused as the template to carry UL message <> and DL message <>, the time quantization granularity () in ReferenceTimeInfo IE is 10ns. Consequently, . Because the implicit PDC does not use delay compensation and therefore does not consume 5ns error caused by the ReferenceTimeInfo-r16 quantization in the network part of synchronization budget, the available Uu-interface error budget for implicit PDC is actually 280ns. ***Observation-5: For implicit PDC, the total Uu error budget is 280ns, instead of 275ns.*** The easiest way to remove this 5.3ns gap is to reduce the granularity of time indication in ReferenceTimeInfo RRC IE. Assume the granularity () in ReferenceTimeInfo time indication needs to satisfy . This requires . It should be noted that the granularity of 2ns or 2.5ns for timing indication is not a new lowest record of the timing report granularity in NR. The UE Rx-Tx timing difference report in LPP protocol can have timing granularity as low as 4Tc, which is also about 2ns, in FR1. error_oneway_propagation_delay_estimation1.gifFigure 2 Implicit PDC timing diagram with signalling flow (Option-2)The term of can be equivalently formulated as , which suggests another signaling flow as shown in Figure 2: * Step-1: UE sends a message to gNB, where the message helps UE and gNB to establish the UL-Tx timing in UE () and UL-Rx timing in gNB (). It does not matter whether this uplink message explicitly contains any information or not. The details is up to RAN2.
* Step-2: The gNB sends to UE a DL message containing a timing information relating to , where corresponds to the DL-Tx timing for the transmission of this DL message. The existing RRC message of ReferenceTimeInfo can be reused/extended in this case. The choice is up to RAN2.
* Step-3: The UE calculates , where is the DL-Rx timing corresponding to the reception of the DL message mentioned in Step-2, and is the UL-Tx timing mentioned in Step-1.

Note that the Option-2 above can be considered a special type of RTT-based PDC, where the information delivered from gNB to UE is not “Rx-to-Tx interval duration”, but “Rx-to-Tx mid-point timing”. For Option-2, the clock synchronization error of implicit PDC (Option-2) is given byThen yields .***Observation-6: A small-enough time indication granularity can make the implicit PDC meet the single Uu error budget for control-to-control scenario, without specification impacts in RAN1 and RAN4.*** ***Proposal 1: Suggest RAN2 to adopt implicit PDC for clock synchronization, with following RAN2 specification impacts.***

|  |  |  |
| --- | --- | --- |
|  | ***Option-1*** | ***Option-2*** |
| ***Design of UL RRC message*** | ***One message that contains the local UL-Tx clock timing () associated with the transmission of the message.*** | ***One message that does not necessarily contain explicit timing information, but should be able to help to uniquely identify local UL-Tx clock timing and local UL-Rx clock timing associated with the message.***  |
| ***Design of DL RRC message*** | ***One message that contains a clock time difference () where is the local clock time associated with the reception of UL RRC message (timing determination could be the same as ReferenceTimeInfo), and is the clock time in the received UL RRC message.*** ***Another message that contains the local clock time associated with the transmission of this message (exactly the same interpretation as for ReferenceTimeInfo).***  | ***One message that contains a Rx-to-Tx “mid-point” (), where is the local clock time associated with the reception of above-mentioned UL RRC message, and is the local clock time associated with the transmission of this DL RRC message.***  |
| ***Timing granularity in the DL/UL message*** | ***2ns or 2.5ns*** | ***4ns*** |

 |

### First round & Second & Third round discussion

**Companies please check the clarifications from OPPO and see if you have any further comments.**

**Feature lead**: There were some initial questions raised by companies for clarification on implicit PDC in RAN1#104bis-e meeting, mainly on the benefits and difference with explicit PDC. However, since the implicit PDC was proposed late (i.e. in RAN1#104b-e) and in RAN#104b-e there was only very initial discussions, the final views from companies are still not clear yet. Therefore, companies are encouraged to provide your further views on implicit PDC method.

**Question 4.4-1: Do you have any further comment/question/views on implicit PDC proposed above?**

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| --- | --- |
| *Company* | *View* |
| CATT | We wonder whether is correct or not.We hope proponent to clarify what is the meaning of above formula.It should be clarified what is difference and what is beneficial point compared to the RTT-based method. |
| Nokia, NSB | In our understanding the described implicit PDC relies on UE correcting the clock error (or also known as clock offset) relative to gNBs clock.A first issue is that the gain seems to be minor for introducing such different method (i.e. just 5ns, assuming no referenceTimeInfo error of implicit) if compared e.g. with the introduction of a new indicator without impacting TA requirements. This can be verified by using the same assumptions as in the contribution from Oppo applied to TA-based Alt.2.Another point that is not clear in the procedure, specially the option 2, is that it seems to compete with the current referenceTimeInfo framework, as a UE applying the procedure don’t seem to make use of timing provided in SIB9. So even for a static UE, which propagation delay does not change, will have to keep exchanging DL and UL signal to get an understanding of gNB timing. While if its said that timing from SIB9 or another form of referenceTimeInfo can be used, then there is no gain compared to RTT or a new low granularity indicator, as same errors would apply.Moreover, the procedure seems not scalable as compared to RTT if it comes to meeting tighter requirements, as it seems relying on same TA loop and RS such as SSB for DL tracking (though the assumption for that is not clear in the description).And last but not least, it is not clear that introduction of such method would only require RAN2 impact, as there should still be specification e.g. for UL Tx timing measurements and DL Rx timing measurements . |
| vivo | If our understanding is correct, Rx-Tx time difference at gNB side and the error of UE receiving singles are the same between explicit and implicit PDC method according to the description. Does the implicit PDC method mean the error of UE transmitting signals can be omitted due to the adjustment based on the interior clock time of UE?  |
| OPPO | Thanks for the comments. @CATT: the formula simply says the clock error between gNB and UE is the difference between * local gNB clock for the middle-point in gNB-side RTT interval, and
* Local UE clock for the middle-point in UE-side RTT interval.

If you believe it is not correct, please be more specific and show the reasoning. @Nokia/NSN: RTT-based PDC and implicit PDC can have the equivalent error performance, if both of following conditions are met for RTT-based PDC: * The DL-Tx error and DL-Rx error are constant between PD estimation and PD compensation; <== RAN1 has debate on this and it is not clear yet how this can be ensured for RTT-based PDC
* The RTT measurements on gNB side and UE side are not messed up by TA command, i.e., it should not happen that one RTT (say on gNB side) is measured before TA application and another RTT (say on UE side) is measured after TA application. <== this issue was raised in earlier meeting but never discussed in detail. But if this is not ensured, a new error term relating to half TAC step should be included and the error performance of RTT-based PDC could be worse than that of TA-based PDC.

I am not sure what you mean by “gain is minor”, because if above two conditions are met, both RTT-based PDC and implicit PDC would observe the same error performance, either “minor” or “not minor”, depending on what is compared. If any of above conditions is not met, implicit PDC would have smaller error than RTT-based PDC if using the same error components on DL/UL Tx/Rx. Implicit PDC option-2 does not assume to use SIB9, because SIB-9 is a common signaling to multiple UE and the timing information delivered from gNB to UE in Option-2 is UE-specific. Option-2 is supposed to use “*DLInformationTransfer*” but indeed needs to modify the RAN2 definition of ReferenceTimeInfo. SIB-9 can work within implicit PDC Option-1. Regarding to scalability, our target till today is to meet RAN2 error budget, rather than pursue a scalable timing error reduction. Meanwhile, the error scalability of RTT-based PDC does not rely on the RTT-based PDC itself but rely on the improvement of RS signal detection, which the implicit PDC can also work with -- right now the implicit PDC assume Te, which is SINR independent. The clock timing recorded in current ReferenceTimeInfo does not require RAN1 spec to say anything. What is carried in signaling flow for implicit PDC (for both Option-1 and Option-2) is a clock time maintained in higher layer, not a PHY layer timing. We do not see RAN1 spec has to handle this.@vivo: Please see our response to Nokia (1st paragraph), regarding to the equivalence between RTT-based PDC and implicit PDC, as well as the condition for that equivalence. Implicit PDC assumes full Te, which includes UL-Tx error.  |
| **Feature lead** | @ OPPOIf the impact from implicit PDC is mainly in RAN2, it seems more appropriate to discuss it in RAN2, since RAN1 may not be able to conclude solutions that is mainly for RAN2?  |
| Nokia, NSB | @OPPO: In our view there are no issues regarding the mentioned conditions for RTT as well as for TA. Our first comment was explicitly if assuming the same lower granularity indicator, i.e. =, applying to TA-based (not RTT) using equation Alt.2, and the same error value assumptions as in OPPO used.=For RTT it should be clear that achievable performance can be just better as it is not restricted by Te like this option. While here, even for a very low granularity, the error is on the edge of the largest Uu budget provided by RAN2 for control-to-control, i.e.On the other hand, if it said that this option would base on other reference signals and bandwidth, then it’s not clear what would be the advantage of specifying this in comparison with RTT or enhanced TA. |
| CATT | We have further comments as follows:1. Comparison with RTT-based PDC, what’s the benefit of this method?2. Whether there is RAN1 spec impact or not? |
| OPPO | @FL: It is RAN1’s responsibility to determine the solution to meet RAN2 error budget. RAN2 spec impact could also apply to TA-based (if TA granularity is reduced) and RTT-based (certain RTT value should be delivered between gNB and UE outside of positioning protocol). If RAN1 cannot handle a solution just because it has RAN2 spec impacts, RAN1 should leave all solutions to RAN2 in the end. In addition, the comment from FL confused us because having no RAN1/RAN4 impacts sounds like a “-” to the solution, rather than a “+”. @Nokia: First of all, because implicit PDC does not have compensation step, the 10ns ReferenceTimeInfo granularity spent in compensation step does not apply to implicit PDC, which mans the total error budget actually available to implicit PDC is 280ns, instead of 275ns. In comparison, RTT-based PDC is still subject to 275ns error budget, and NOkia’s calculation which results in 280ns would exceed 275ns. So the two solutions are not comparable, since one meets the budget but another does not. In addition, we doubt whether people can safely assume TA indication granularity can be reduced as small as 4.4ns. Any calculation based on this assumption is very questionable. @CATT:1. Comparing to RTT-based PDC, the implicit PDC avoids:
* The trouble caused by the additional error (which RAN1 did not study yet in this WI) in the case where RTT measured by gNB and RTT measured by UE are separately taken before and after of a TA command application.
* The SINR-dependent RTT measurement accuracy if relying on PRS.
* Two different error formula to be handled in parallel, w/o being able to determine which one is correct.
* The discussion of UE’s PRS capability in use of PDC and the use of TRS when UE does not have PRS capability. Also avoid RAN4 discussion on TRS-based synchronization performance.
1. As I said many times in email discussion as well as in our contribution, implicit PDC has no spec impacts to RAN1 and RAN4.
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## Way forward on PDC in RAN1 for Rel-17

Nokia (R1-2106638) propose to adopt Recommendation 3 from RAN#92e plenary email discussion to move forward below.

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| **On the way forward on PDC in RAN1**The meeting schedule for the RAN working groups involved in PDC in Q2 2021 is as following:* RAN1 has 3 meetings remaining in 2021:
	+ August (RAN1#106-e 16/08-27/08)
	+ October (RAN1#106-bis-e 11/10-19/10)
	+ November (RAN1#107-e 11/11-19/11).
* RAN2 has only two meetings remaining in 2021:
	+ August (RAN2#115-e 08/08-27/08)
	+ November (RAN2#116-e 01/11-12/11).
* RAN3 similarly has also only two meetings remaining in 2021:
	+ August (RAN3#113-e 16/08-26/08)
	+ November (RAN3#114-e 01/11-11/11)
* RAN4 similarly has also only two meetings remaining in 2021:
	+ August (RAN4#100-e 16/08-27/08)
	+ November (RAN4#101-e 01/11-12/11).

As agreed in RAN#92-e the first RRC parameter list should be provided to RAN2 to handle in RAN2#116-e which means that RAN1 should send an LS latest in RAN1#106-bis-e. This leaves RAN1 with RAN1#106-e and RAN1#106-bis-e to complete the ongoing analysis. If RAN1 cannot reach any conclusion without RAN4 involvement, the earliest time RAN1 can receive an LS reply from RAN4 is by RAN1#107-e, assuming the optimistic timeline where RAN1 sends out an LS to RAN4 in RAN1#106-e. RAN4 will not be able to treat the topic before RAN4#101-e as RAN4#100-e and RAN1#106-e completely overlap in time, but can only treat the LS and generate an LS reply in RAN4#101-e. In short, RAN1 needs to decide fast and needs to avoid being dependent on an LS to RAN4 to reach a decision in order to satisfy the RRC parameter list deadline. **Observation 1: If RAN1 sends out an LS to RAN4 in this meeting, the reply LS will be available earliest in the November meeting (RAN1#107-e), which exceeds to agreed deadline for sending an LS to RAN2 on the RRC parameter list.**In RAN#92e the possibility of down-scoping on PDC was discussed. The summary of the email discussion can be found in RP-211569:

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| Based on the discussions in the final phase, the following Recommendation3 (revised during final phase) was supported by or was acceptable to at least Nokia/NSB, Sony, Huawei/HiSi, Intel, Bosch, DOCOMO, LG, Ericsson, Huawei/HiSi, and Turkcell (10 companies). * **Recommendation3**: Provide the following RAN guidance on *Propagation delay compensation enhancements [RAN2, RAN1, RAN3, RAN4]*
	+ Support TA-based propagation delay compensation based on the Rel-15/16 timing advance procedure in Rel-17 without changes on existing TA requirements/procedures for use cases with less tight time synchronization requirements such as smart grid.
	+ RAN1/2/4 to focus on RTT-based propagation delay compensation enhancements in Rel-17.

Working groups should strive to minimize the impact on UE complexity.However, ZTE, MTK, OPPO, vivo, CATT, and CMCC (6 companies) still maintained negative views on taking this proposal. Key concerns raised were that RAN1 needs to wait for RAN4’s input on TA-based PDC and more study needs to be done for RTT-based PDC before making such decision.An alternative to Recommendation3 is the following compromise suggested by CATT in the last hours of the final phase email discussions.* **Recommendation3A**: Provide the following RAN guidance on *Propagation delay compensation enhancements [RAN2, RAN1, RAN3, RAN4]*
	+ RAN1 to send an LS to RAN4 in RAN#106-e to check the feasibility and potential enhanced value for Te and TA command indication granularity,
	+ RAN1 and RAN2 to focus on RTT-based propagation delay compensation enhancements while waiting for a reply LS from RAN4.

Working groups should strive to minimize the impact on UE complexity.Recommendation3A will allow RAN1 and RAN2 to proceed with the work on RTT-based PDC enhancements while RAN4 is formulating their response to RAN1. If RAN4 response on TA-based PDC is not made available on time or if their response is that TA-based PDC is not feasible to meet certain requirements, RAN1 and RAN2 can at least have RTT-based PDC specified in Rel-17 to meet all TSN requirements.**Given the significant number of companies (6 companies) with concerns on Recommendation3, the moderator suggests taking Recommendation3A as a compromise to ensure the support of propagation delay compensation for TSN in Rel-17.** |

With the observation in mind, it is strictly needed that RAN1 reaches a conclusion as fast as possible, and latest in the October RAN1 meeting (RAN1#106-bis-e). We strongly see the need for RAN1 to select an option, possible a compromise to ensure that a PDC framework is in place in Release-17. Further enhancements can be in the scope of Release-18. Still with the observation 1 in mind, **Recommendation 3A is not a feasible** way forward as RAN1 will not be able to make a decision before RAN4 sends the LS reply. Therefore, our proposed way forward in RAN1 is adopt **Recommendation 3**.**Proposal 1: RAN1 must make a compromise in order to move PDC forward in time for support in Release-17. It is proposed to discuss and adopt Recommendation 3 from the RAN plenary email discussion.** |

**CATT (R1-2106966) propose the following.**

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| **CATT (R1-2106966)****Proposal 4: TA-based propagation delay compensation can be considered for enhancement for propagation delay compensation with high priority. After the above-mentioned two LSs to RAN2/RAN4 related to the TA-based enhanced PDC are approved by RAN1, RAN1 can study RTT-based propagation delay compensation in parallel.** |

**Feature Lead:** There were fierce discussions in RAN#92-e on the way forward on PDC in RAN1. However, no any consensus is able to be achieved. For now, I don’t see there is any chance to agree on any of the recommendations based on the discussion in RAN, so let’s not to discuss this aspect at the beginning. However, if the progress for TA-based PDC and RTT-based PDC is still very difficult based on the discussions in this meeting, we may have to re-discuss this again at the end of RAN1#106-e.

# Continuation of discussion from Friday GTW

Thank very much for all for being flexible during the Friday GTW. Before we trigger the 4th round email discussion, I would like to continue the discussion on the remaining proposals from Friday GTW quickly, to see if any chance for us to achieve some consensus by email.

**Proposal 4.3.3-1:Support the following Rx-Tx configurations for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.**

* **At least one CSI-RS for tracking (TRS) configuration for Rx – Tx time difference estimation at UE side if PRS is not configured**
* **At least one SRS configuration for Rx – Tx time difference estimation at gNB side**

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| Supporting companies | *Nokia, NSB, Huawei, HiSilicon, Qualcomm, Intel, Samsung, vivo, CATT, Ericsson, ZTE* |
| Objecting companies |  |

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| --- | --- |
| *Company* | *View* |
| **Feature lead** | @ allPlease also share if you have strong concern if we delete “for tracking (TRS)” from the proposal, per the comment from OPPO.  |
| OPPO | Several clarifications are needed on the proposal: 1. The proposal says “support a kind of configuration in which the gNB has to configure UE with TRS if gNB does not configure UE with PRS”. If this is the only configuration to be allowed, our question is: do we really need such restriction to gNB? Could UE use general CSI-RS (not for tracking purpose) or SSB+CSIRS when both PRS (for RTT purpose) and TRS (for RTT purpose) are not configured? What RAN1 agreed is “CSI-RS for tracking (TRS) ***can be*** used for Rx – Tx time difference estimation at UE side, if PRS is not configured for the UE” -- it does not say TRS has to be used, then why the TRS for RTT estimation has to be configured (if PRS is not)?

Feature lead>> As suggested by Nokia below, I am fine to remove “**for tracking (TRS)**” from proposal if you feel more comfortable with it, though I think it is more concrete to use CSI-RS for tracking since so far we only have explicit agreement on this. 1. Similar for SRS configuration: does gNB have to rely on “SRS configured for RTT estimation”, rather than other (e.g., general purpose) SRS from the same UE? Isn’t this “at least one” a restriction/requirement to gNB behavior that UE does not need to care about?

Feature lead>> If gNB already configure the SRS configuration for RTT measurement, that means UE would transmit the corresponding SRS, right? Then why UE doesn’t need to care about? In addition, the intention is not to put any limitation at the gNB side, gNB can have some flexibility though I think most likely gNB would rely on the SRS it configures gNB to send. The above two bullets also lead to another question: would be any difference per UE behavior in specification between UE being configured with just one TRS/SRS for RTT estimation and UE being configured with more than one TRS/SRS for RTT estimation? Feature lead>> This kind of details would be up to further discussion. However, in my understanding, there is not much difference expected.  |
| Nokia, NSB | Support the proposal.We would be fine removing "for tracking (TRS)" from the proposal if that helps progressing. gNB can just ensure there is at least an NZP-CSI-RS-ResourceSet configured for the UE for Rx-Tx time difference estimation.And regarding SRS configuration for Rx – Tx time difference, our understanding is that this should not limit to SRS resources from positioning.Feature lead>> I will ask companies to check if they are ok to remove for tracking.  |
| ZTE | We are fine with the FL proposal. We think TRS is the best candidate if PRS is not configured. Any reason not to use it?Feature lead>> OPPO feel that any CSI-RS can be used for the measurement, thus no need to limit that only TRS is configured.  |
| Ericsson | We are fine with the proposal. On the other hand, we prefer to remove “if RTT-based… is supported”. It is better that RAN1 can agree that RTT-based is supported, then making detailed proposals to enable it.Feature lead>> Agree with you. However, before we agree the equations for RTT-based PDC and have some rough evaluation on the RTT based performance, I think it would be very difficult for us to have agreement in this meeting to say RTT-based PDC is supported. The key thing at this meeting for us is to agree with the equations for PDC to move forward in the next meeting.  |
| CATT3 | We are fine with FL proposal. We would like to keep “if RTT-based propagation delay compensation is supported” before we finish the evaluation on RTT-based PDC yet. |
| Samsung | OK to remove "for tracking (TRS)". We’d like to keep “if RTT-based … is supported” |
| Intel | Still support the proposal |
|  |  |

**Revised Proposal 4.3.3-2:If RTT-based propagation delay compensation is supported and performed at the UE side, the Rx-Tx measurement report provided from the gNB to the UE should include at least:**

* **Rx-Tx measurement at fixed granularity ~~(FFS which granularity)~~**
* **FFS whether to include SRS-Resource-ID**

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| Supporting companies | *Nokia, NSB, vivo, Huawei, HiSilicon, Qualcomm, CATT, Intel, ZTE,*  |
| Objecting companies |  |

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| --- | --- |
| *Company* | *View* |
| OPPO |  We are fine in principle, except the “**FFS which granularity**”. It is a tradition (as in positioning and Rel-16 IAB for Timing Delta MAC-CE) that the RTT indication granularity and value range are determined in RAN4, not RAN1. Feature lead>> I can remove it if you prefer that way better, and yes that is not RAN1 scope I think. For SRS-resource-ID, here is what 38.305 says for multi-RTT positioning:Table 8.10.2.4-1: Requested UL-SRS transmission characteristics information that may be transferred from LMF to gNB.

|  |
| --- |
| Information  |
| Number Of Transmissions/duration for which the UL-SRS is requested |
| Bandwidth |
| Resource type (periodic, semi-persistent, aperiodic) |
| Number of requested SRS resource sets and SRS resources per set |
| Pathloss reference: - PCI, SSB Index - DL-PRS ID, DL-PRS Resource Set ID, DL-PRS Resource ID |
| Spatial relation info - PCI, SSB Index - DL-PRS ID, DL-PRS Resource Set ID, DL-PRS Resource ID - NZP CSI-RS Resource ID - SRS Resource ID - Positioning SRS Resource ID |

It can be seen SRS-Resource-ID belongs to “spatial relation info”. Given what RAN1 care about here is timing relation, we would like to get clarification why RAN1 needs FFS on SRS-Resrouce-ID for RTT measurement purpose. Feature lead>> Nokia explained well the intention. Anyway since whether to support more than one configuration is not decided yet, you could see that I only put FFS here. Hope you are fine with it for now.  |
| Nokia, NSB | Support the proposal.Regarding comment from @OPPO. In our understanding the SRS-Resource-ID is to identify which SRS configuration is associated to the specific Rx-Tx measurement being sent by gNB to UE. If only a single SRS configuration is supported and/or only a single UL/DL RS transmission is possible between Rx-Tx reports, so none SRS-Resource-ID is needed though which is why we have the FFS. |
| ZTE | We are fine with the proposal.  |
| Ericsson | We see the intention of the proposal. But we wonder why “Rx-Tx measurement at fixed granularity”.* “Rx-Tx measurement” seems to refer to “gNB Rx-Tx time difference”. Suggest to use “gNB Rx-Tx time difference” directly.

Feature lead>> I think ok to change it to make it clearer. * What’s “fixed granularity” intended?
	+ In our understanding, there are two metrics associated with gNB Rx-Tx time difference. (1) reporting resolution of the report mapping table; (2) measurement accuracy requirement. It seems that the intention is (1). Thus, suggest to use “reporting resolution” instead.
	+ Also it’s puzzling why ‘fixed’? In our understanding, the reporting resolution is at least a function of SCS, not fixed. Suggest change to “at a predefined granularity” or “at a given granularity”.

Feature lead>> Fine to change accordingly.  |
| CATT3 | We are fine with FL proposal. |
| Samsung | Fine with the proposal. Also ok on Ericsson.  |
| Intel | Still support the proposal |
|  |  |

**Revised proposal 4.3.1-1:**

**Working assumption:**

**Take the following two alternatives as the equation for evaluation of the overall time synchronization error for RTT-based propagation delay compensation:**

* **Alt. 1:**
	+ is to reflect the error due to indication granularity of Rx-Tx time difference
	+ and reflects the measurement inaccuracy of gNB Rx-Tx time difference, and the measurement inaccuracy of UE Rx-Tx time difference, respectively.
* **Alt. 2:**
	+ is to reflect the error due to indication granularity of Rx-Tx time difference
	+ *[Note: Alt.2 assumes that the time of PD estimation is close to the time of PD compensation, in which case the DL frame timing error and BS transmit timing error for propagation delay estimation is correlated to that for the transmission of RRC signaling carrying the reference time clock]*

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| Supporting companies | Nokia/NSB (*errorUE,UL,TX* can be removed) |
| Objecting companies | OPPO, Ericsson |

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| --- | --- |
| *Company* | *View* |
| Feature lead | Similar as TA-based PDC, one way to move forward is to take both alternatives as the working assumption for RTT-based PDC. Then next meeting, people can provide corresponding evaluations for RTT-based PDC in order to help us decide whether to support RTT-based PDC. In addition, do you support the updated note 2 under alt.2 from OPPO? * + *~~[~~Note: Alt.2 assumes that gNB makes the times of ~~PD estimation~~ RTT measurements in gNB and UE, as well as the time of RTT indication, ~~is~~ close to the time of ~~PD compensation~~ delivery of RefernceTimeInfo, in which case the DL frame timing error and BS transmit timing error for ~~propagation delay estimation~~ ~~is~~ UE/gNB RTT measurements are ~~correlated to~~ respectively the same as ~~that~~ those for the transmission of RRC signaling carrying the reference time clock~~]~~*
 |
| OPPO | First of all, we understand the proposal is purely for UE-based PDC, which can be clarified at the beginning. Feature lead>> Why it is only for UE based PDC? I think it can be applied to both gNB based and UE based. Note that can be applied to gNB indicate to UE, and UE indicate to gNB also. Secondly, based on the discussion so far, even for companies agreeing on the same formula, they may have different understanding to the timing variables in that formula, e.g., with confusion whether the timing reference taken at antenna connector or not. It is better to mark in the proposal for each timing variable what timing reference it uses. As for the FL response to our earlier comments (copied below), OPPO:This mismatch of understanding among companies can be traced back all the way to the formula given in section 3.1:  (1)which can be equivalently reformulated as  (2)The left side of (2) is “the one-way propagation delay from gNB baseband to UE baseband”, since ReferenceTimeInfo timing is not taken at antenna connector (according to 38.331); in contrast, the right side of (2), according to FL and quite some proponents of RTT\_based PDC, is “the one-way propagation delay from gNB antenna connector to UE antenna connector”, then the question is how the values on two sides of (2) can be equal, since antenna-to-antenna PD should be strictly less than baseband-to-baseband PD.Feature lead>> Thanks for your further comments. Note that it is not all right side of (2) take reference at antenna connector, e.g. the following two highlight in red is still the same as what we defined for TA-based PDC. Unfortunately it is not our understanding that the two red terms are supposed to seal the gap between “reference at baseband” and “reference at antenna connector”, because the that RAN1 came up with is [-65,+65]ns or [-32.5,+32.5]ns, and then * With 0 being the middle point of the error range, cannot include the (signal travel + radio processing) delay (which is definitely positive) between two different time references. Similar argument goes for , which corresponds to a range of [-100,+100]ns.
* RAN1’s earlier discussion took from TAE defined in 38.104, and TAE is defined by using reference at antenna connector.

In a word, there seems nothing on right side of (2) to make the right side of (2) step away from a antenna-to-antenna propagation delay and to match a baseband-to-baseband propagation delay as on left side of (2). Our concern remains. Feature lead>> So follow the logic you provide here, that means the formula we took for TA-based PDC is not correct either, since the left side is based on baseband reference point while the right side is based on the antenna connector reference point. Anyway, as I explained above, the time interval between the base band and the antenna connector would be included in the measurement accuracy already, if look at it from this aspect if you want you can consider Rx-Tx time difference is defined with reference point of baseband, however as I explained in previous section, it should not be the same as what we defined for TA-based PDC regarding the UE transmit timing error. However, let me set a question to check people view on this. Thirdly, for Alt-2, the formula is built upon an assumption as outlined in Note, which says the PD estimation and PD compensation should be close enough to each other in time. Three issues for this note: * The formula assumes the errors are not just correlated, but actually constant over a time window.
* We want to make sure this is gNB’s responsibility, since if gNB configures UE to use PRS or TRS, it is gNB that decides when RTT estimation is done for both gNB and UE.
* Differently from TA-based PDC, RTT-based PDC needs to deliver gNB-side RTT to UE, which means all of following three tasks should happen closely before delivery of ReferenceTimeInfo in order to reach Alt-2 formula.
	+ gNB measures SRS-based RTT on gNB side,
	+ gNB delivers gNB-side RTT to UE,
	+ UE measures UE-side RTT based on configured PRS

A modified note is outline below to reflect the fact of Alt-2:* + *~~[~~Note: Alt.2 assumes that gNB makes the times of ~~PD estimation~~ RTT measurements in gNB and UE, as well as the time of RTT indication, ~~is~~ close to the time of ~~PD compensation~~ delivery of RefernceTimeInfo, in which case the DL frame timing error and BS transmit timing error for ~~propagation delay estimation~~ ~~is~~ UE/gNB RTT measurements are ~~correlated to~~ respectively the same as ~~that~~ those for the transmission of RRC signaling carrying the reference time clock~~]~~*

We wonder how challenging it is for gNB to maintain “close enough” relation, given RTT indication is subject to time spent over HARQ, and such “close enough” relation could be needed at the same time for all UEs receiving ReferenceTimeInfo when ReferenceTimeInfo is delivered in SIB9. In our view, comparing to Alt-1, Alt-2 is too optimistic and therefore should be dropped. Feature lead>> I think you have points here. However, my original thinking is that PD estimation in the current note can cover all the cases you mentioned above, i.e. *RTT measurements in gNB and UE as well as the time of RTT indication*. If you check the comment from ZTE, they feel the updated note from OPPO may cause some misunderstanding. Anyway, let me set a question explicitly to check the views from companies.  |
| CATT2 | For Alt.2, we want to clarify why the parameter has the square brackets .Feature lead>> A few companies still wants to include , while some others don’t like it, that is why I put it in bracket.  |
| Nokia, NSB | Support the proposal. And we think that can be removed from Alt.2.Feature lead>> A few companies still wants to include , while some others don’t like it, that is why I put it in bracket.  |
| ZTE | First, we think should be kept in the Alt.2. In addition, we think the coefficient of the should be 1/2. So maybe we can add 1/2 in the bracket before it?For note under Alt. 2, we share the similar view that the RTT measuring operation close to the SFN boundary (e.g., indicated by referenceSFN) transmission is the prerequisite of the Alt. 2. This needs the network scheduling. However, for the updated note from OPPO, it is our understanding that it implies the network should ensure the DL frame timing error and BS transmit timing error in the RTT measurement are the same as that when the UE detects the reference SFN boundary, respectively. However, the DL frame timing detection is the UE behavior. And it cannot be controlled by the network. So to avoid such misunderstanding, we suggest removing the ‘DL frame timing error’ in the updated note and adding another note-“It is up to the UE to ensure the DL frame timing error are the same in the two procedures on top of the above operation.”Alternatively, we are fine with the note from FL. For the Alt.1, given that we cannot achieve the same understanding on the Rx-Tx time difference, maybe we can suggest asking RAN4 for clarification for this by sending an LS with the following question. For example, Whether or not the and/or are included in the Rx-Tx time difference at gNB (i.e., ).Whether or not the and/or should be considered in addition to if they are not included.Feature lead>> I think you mean and not , since is just an reporting granularity, not he measurement accuracy. I feel if we ask too many this kind of question to RAN4, it will increase the workload at RAN4 much unfortunately, so my intention is that if this is only for evaluation, and later if we feel that anyway it may not impact the decision on whether to support RTT, let’s not to send it RAN4 now. If based on the evaluation for different alternatives above and we find that whether to include these two parameters are the crucial aspect to decide whether to support RTT based PDC, then we can consider to send LS.  |
| Ericsson | We support Alt 1. We don’t understand why Alt 2 could work. For the RTT based method, the measurement quantities are Rx – Tx time difference (gNB side and UE side). For example, Proposal 4.3.3-1 explicitly states so. Then it stands to reason that the error components should be the error of measuring Rx – Tx time difference at gNB side and UE side. It is very strange to use a formula similar to that of TA-based.We can’t support the proposal unless Alt 2.Feature lead>> I totally understand your position. However, based on the current situation, it is really difficult to go with Alt.1 directly. In addition, I think the proponents of Alt.2 has some points there also, since so far the measurement accuracy for PDC is not available yet, thus ok to use parameters that similar as TA-based PDC to evaluate RTT-based PDC as long as we pick the parameter carefully to match the principle for RTT-based PDC. Otherwise, it seems no way to move forward.  |
| CATT3 | We support adding 1/2 in the bracket before the  |
| Samsung | We support alt 2 with , and support adding 1/2 for .The reason of adding is because there will have an error at UE side for transmitting, which caused by, UE intend to transmit at t1, but actually transmit at t2. This value should be smaller than Te, due to better DL sync. But we think RTT based method cannot get rid of this transmission error, which is due to hardware. For alt 1, the measurement error is not enough for PDC. |
| Intel | Support the proposal to move forward, by adding brackets to components concerned by some companies. |
|  |  |
|  |  |

## 4th round email discussion

Based on the discussion above, some of the proposals are modified for final check from companies.

**Proposal 4.3.3-1:Support the following Rx-Tx configurations for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.**

* **At least one CSI-RS for tracking (TRS) configuration for Rx – Tx time difference estimation at UE side if PRS is not configured**
* **At least one SRS configuration for Rx – Tx time difference estimation at gNB side**

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| --- | --- |
| Supporting companies | *Nokia, NSB, Huawei, HiSilicon, Qualcomm, Intel, Samsung, vivo, CATT, Ericsson, ZTE* |
| Objecting companies |  |

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| --- | --- |
| *Company* | *View* |
| **Feature lead** | It seems all companies are fine with the proposal. Not sure if OPPO can accept it if we still keep “for tracking (TRS)”.@ OPPO Can you live with the proposal considering all companies are fine with it? Since we only have explicit agreement to use CSI-RS for tracking (i.e. TRS) for the measurement, I think it is ok to explicitly mention it. Of course, for the signaling design itself, it is up to RAN2, e.g. whether to configure a TRS configuration for PDC, or configure a CSI-RS configuration for PDC while the configuration is similar as that for TRS.Of course from my side I think it is ok to remove “for tracking (TRS) also, just not sure the views from companies.  |
| CATT | We are fine with this proposal with removed “for tracking (TRS)” |
| OPPO | Our concern is not on “TRS”. The proposal actually says: as long as RTT-based PDC is a Rel-17 supported feature, gNB has to configure specific DL/UL RS resources (for PDC purpose) for each UE [even when gNB does not know yet whether the UE would do PDC]. This sounds like a quite strong requirement system-wide. We think the following bullets are better (which says the legacy general-purpose RS can be used, i.e. there is no need to mandate RS configuration dedicatedly for RTT measurement): * **~~At least~~ one CSI-RS for tracking (TRS) configuration ~~for Rx – Tx time difference estimation at UE side~~ if PRS is not configured, and**
* **~~At least~~ one SRS configuration ~~for Rx – Tx time difference estimation at gNB side~~**
 |
| Nokia/NSB | Support.  |
| Vivo | We are fine with the proposal. |
| HW/HiSi | Support |

**Revised Proposal 4.3.3-2:If RTT-based propagation delay compensation is supported and performed at the UE side, the Rx-Tx measurement report provided from the gNB to the UE should include at least:**

* **gNB Rx-Tx time difference at a given granularity ~~measurement at fixed granularity~~**
* **FFS whether to include SRS-Resource-ID**

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| --- | --- |
| Supporting companies | *Nokia, NSB, vivo, Huawei, HiSilicon, Qualcomm, CATT, Intel, ZTE, Samsung*  |
| Objecting companies |  |

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| *Company* | *View* |
| Feature lead | For Rx-Tx time difference measurement reporting for positioning, they use resolution as the granularity as defined in 38.133 section 13.2. In addition, for positioning, they will also report the k value to determine the resolution and k can be in the range from 0 to 5. However, for PDC I think we need further discussion on what kind of granularity we need in order to meet budget first, not clear right now whether we can directly reuse the resolution that is similar as positioning. Hope E// can accept we don’t mention resolution explicitly at this stage. @allPlease check if you are ok with the modified proposal, especially if you have strong concern please share it asap.  |
| CATT | We are fine with updated proposal. |
| OPPO | We wonder what information is provided by the proposal, given “**the Rx-Tx measurement report provided from the gNB**” should certainly [by definition] include “**gNB Rx-Tx time difference**”. As we mentioned earlier, it is better to ask RAN4 for the decision of granularity and value range, because* What 38.133 defined for gNB Rx-Tx difference report is sent over wired network from gNB to LMF, while what RAN1 needs now is something sent wirelessly from gNB to UE.
* The smallest granularity in current spec (with k=0) results in 21 bits for gNB Rx-Tx difference. It is better to leave RAN4 to decide whether this is ok for UE handling.

Regarding to whether the PRS-based RTT measurement and CSI-RS based RTT measurement should share the same report format (granularity, RTT value range, we do not see any issue in sharing, but it is better to ask RAN4 as well to confirm.  |
| Nokia/NSB | We are fine with updated proposal. |
| HW/HiSi | Support |
| Samsung | Fine with the update |

**Revised proposal 4.3.1-1:**

**Working assumption:**

**Take the following two alternatives as the equation for evaluation of the overall time synchronization error for RTT-based propagation delay compensation:**

* **Alt. 1:**
	+ is to reflect the error due to indication granularity of Rx-Tx time difference
	+ and reflects the measurement inaccuracy of gNB Rx-Tx time difference, and the measurement inaccuracy of UE Rx-Tx time difference, respectively.
	+ ***Support:*** *Ericsson, Huawei, HiSilicon, LG, Qualcomm, OPPO, vivo*
* **Alt. 2:**
	+ is to reflect the error due to indication granularity of Rx-Tx time difference
	+ *[Note: Alt.2 assumes that the time of PD estimation is close to the time of PD compensation, in which case the DL frame timing error and BS transmit timing error for propagation delay estimation is correlated to that for the transmission of RRC signaling carrying the reference time clock]*
	+ ***Support:***
		- *Nokia, NSB, Intel: Without the parts highlight in red*
		- *ZTE, CATT, Samsung: With the parts highlight in red*

|  |  |
| --- | --- |
| Supporting companies | Nokia/NSB (*errorUE,UL,TX* can be removed) |
| Objecting companies | OPPO, Ericsson **Ericsson**: Only support Alt.1**OPPO**: Have concern on the note for Alt.2 and also want to clarify the reference point for timing variables for Alt.1, which as the question I set below for companies to check.  |

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| --- | --- |
| *Company* | *View* |
| Feature lead | Similar as TA-based PDC, one way to move forward is to take both alternatives as the working assumption for RTT-based PDC. Then next meeting, people can provide corresponding evaluations for RTT-based PDC in order to help us decide whether to support RTT-based PDC. @allPlease check my replies to your comments in the previous sections also before commenting here.  |
| ZTE | Without the consensus on the understanding of the and , we have concern on Alt. 1. We think it is unfair that we use the different error components for evaluation and further comparison. According to the clarification from FL at the beginning captured blow, we would like to confirm that it is the common understanding that the the BS detection error is included in and UE detection error is included in in the view of Alt.1 proponents, right?

|  |
| --- |
| The first issue is whether to consider UE and BS transmit timing error. According to the definition for Rx – Tx time difference below, the reference point for transmit measurement is antenna connector as highlight in yellow below, it seems in this case and don’t need to be considered. |

Taking the UE Rx-Tx time difference as example, the TUE-RX is the UE received timing of downlink subframe #i from a Transmission Point (TP) [18], defined by the first detected path in time. So the UE detection error should be there and considered. We don’t think we achieve the consensus on whether and are considered as discussed in Q4.3-1. So maybe we can add these two components in the Alt. 1 within the brackets. Sorry for the late comments to Alt. 1. Regarding the LS suggested by us, thanks FL for spotting the typo. We think RAN4 can prioritize the discussion if the work load is high. So we prefer to include this issue in the LS due to the potential impact to the evaluation.  |
| CATT | We prefer adding the bracket for and in Alt.1 and it is reflected in LS to RAN4We are fine with this proposal with our suggestion. |
| OPPO | Now we have additional (but not new) concern on both Alt-1 and Alt-2: both formula do not contain any error term caused by inconsistent RTT measurements between gNB and UE, i.e., there is a UL-Tx timing change happening between gNB RTT measurement and UE RTT measurement. Such error is possible now because both gNB RTT measurement and UE RTT measurement have to be bound with specific DL RS and UL RS that are configured, while both TA command and UE autonomous UL Tx timing adjustment are on-demand behaviors that are difficult to arrange in advance. If the formula does not contain the corresponding error term, RAN1 should provide the solution to avoid such errors, which has not been discussed yet. We also have concern for the situation that RAN1 keeps having three error models for TA-based PDC and three error models for RTT-based PDC, and even stop trying now to nail down which error modeling should be chosen. Then how to compare the error performances in the end?  |
| Nokia, NSB | Support. Looking at the current situation, taking this working assumption seems to be the only agreeable possible option considering where companies stand.  |
| Vivo | For the working assumption, the premise is ‘If RTT-based propagation delay compensation is supported’, right? |
| HW/HiSi | We support, agree with the reasoning of Nokia. This seems to be the only way forward. |
| Samsung | Agree with vivo’s comment. |

**Question 5.1-1: *Do you have strong concern to replace the note in Alt.2 by the following note?***

* + *[Note: Alt.2 assumes that the time of PD estimation (i.e. including Rx-Tx time difference measurement at both gNB and UE sides, as well as the time of RTT indication) is close to the time of PD compensation (i.e. delivery of RefernceTimeInfo), in which case the DL frame timing error and BS transmit timing error for propagation delay estimation is correlated to (i.e. respectively the same as) that for the transmission of RRC signaling carrying the reference time clock]*

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| *Company* | *View* |
| CATT | We hope proponent for alt.1 to clarify why Alt.1 needn’t this note.In addition, if alt.1 considers the worst case, we wonder whether evaluation results of Alt.1 for RTT-based PDC can meet the single Uu interface budget for control-to-control from RAN2 or not. |
| OPPO | We do have the concern for removing the wording saying the responsibility is on gNB side. Based on the agreement so far, it is gNB that controls everything: directs UE when to receive PRS/CSIRS, when to send SRS, when to receive gNB Rx-Tx difference report, and when to receive ReferenceTimeInfo IE. A modification can be as following:* + *~~[~~Note: Alt.2 assumes that gNB makes the time of PD estimation (i.e. including Rx-Tx time difference measurement at both gNB and UE sides, as well as the time of RTT indication) ~~is~~ close to the time of PD compensation (i.e. delivery of RefernceTimeInfo), in which case the DL frame timing error and BS transmit timing error for propagation delay estimation is correlated to (i.e. respectively the same as) that for the transmission of RRC signaling carrying the reference time clock~~]~~*

  |
| Nokia, NSB | We think that adding more may just cause more confusion. For example, “*as well as the time of RTT indication*” is not really needed, as the measurement error does not depend on the timing of indication. And the “*i.e. delivery of RefernceTimeInfo”,* also may confuse, because the measurement error is not related to the time of delivery of referenceTimeInfo but to the determination of the corresponding SFN boundary.  |

**Question 5.1-2: *Do you agree to add an additional note to clarify the reference point for the timing variables in Alt.1? If you answer is yes, please provide your views on the reference point for each timing variable, i.e.,,,and*** *.*

|  |  |
| --- | --- |
| *Company* | *View* |
| ZTE | We have no strong views since the reference point has been clarified in the definition.  |
| CATT | We hope proponent to clarify the motivation of redefining the reference point for the timing variables in Alt.1. |
| OPPO | After reviewing the complete PDC procedure, we tend to be ok for not asking for further clarification of reference points of those timing error components.  |
| Nokia, NSB | We don’t see the need for further clarification as the reference points should be clear. If there is any considerable error arising from internal implementation, that should be within the error components already defined.  |
| HW/HiSi | We don’t think that a further clarification is needed. |

# References

1. RP-201310, *Revised WID: Enhanced Industrial Internet of Things (IoT) and ultra-reliable and low latency communication (URLLC) support for NR* , Nokia, Nokia Shanghai Bell
2. R1-2100024 Reply LS on propagation delay compensation enhancements
3. [R1-2106590](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2106590.zip) Discussion on propagation delay compensation enhancements vivo
4. [R1-2106638](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2106638.zip) Discussion on enhancements for propagation delay compensation Nokia, Nokia Shanghai Bell
5. [R1-2106682](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2106682.zip) Propagation Delay Compensation Enhancements for Time Synchronization Ericsson
6. [R1-2106738](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2106738.zip) Discussion on propagation delay compensation enhancements ZTE
7. [R1-2106883](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2106883.zip) Discussion for propagation delay compensation enhancements Samsung
8. [R1-2106966](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2106966.zip) Discussion on propagation delay compensation enhancements CATT
9. [R1-2107276](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107276.zip) Enhancement for support of time synchronization OPPO
10. [R1-2107340](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107340.zip) Enhancements for support of time synchronization for enhanced IIoT and URLLC Qualcomm Incorporated
11. [R1-2107447](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107447.zip) Discussion on propagation delay compensation enhancements LG Electronics
12. [R1-2107495](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107495.zip) Discussion on propagation delay compensation for time synchronization MediaTek Inc.
13. [R1-2107587](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107587.zip) Further analysis and design considerations for propagation delay compensation methods Intel Corporation
14. [R1-2107678](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107678.zip) Enhancements for support of time synchronization Huawei, HiSilicon
15. 3GPP RAN1#105-e, R1-2104171, Reply LS on UE transmit timing error

# Appendix Agreements in the past meetings

**RAN1#102-e**

Agreements:

* Take the following use cases as the representative use cases for further study on propagation delay compensation enhancements in Rel-17.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **User-specific clock synchronicity accuracy level**  | **Number of devices in one Communication group for clock synchronisation** | **5GS synchronicity budget requirement** **(note)** | **Service area**  | **Scenario** |
| 2 | Up to 300 UEs | ≤900 ns           | ≤ 1000 m x 100 m | * Control-to-control communication for industrial controller
 |
| 4 | Up to 100 UEs | <1  µs | < 20 km2 | * Smart Grid: synchronicity between PMUs
 |

Agreements:

* ±8\*64\*Tc/2μ as the TA indicating error is assumed in the evaluation.

Agreements:

For 5GS synchronicity budget requirement,

* One Uu interface is assumed for smart grid.
* Two Uu interfaces are assumed for control-to-control.

Agreements:

For BS transmit timing error, further study the following three options:

* **Option 1**:65 ns
* **Option 2**:±130ns for the indoor scenario and ±200ns for the smart grid scenario
* **Option 3**:82.5 ns

Agreements:

The value defined in Table 7.1.2-1 for initial transmit timing error (Te) in TS 38.133 should be considered for evaluation of the time synchronization.

Agreements:

Asymmetry between downlink and uplink channel for control-to-control scenario is not considered.

Agreements:

100 ns is assumed for BS detecting error.

Agreements:

Timing advance adjustment accuracy defined in Table 7.3.2.2-1 in TS 38.133 is assumed for evaluation of the time synchronization.

Agreements:

Both 15 kHz and 30 kHz are assumed for both control-to-control and smart grid for evaluation of the time synchronization.

Agreements:

Send an LS to RAN2 with the content including

* Inform RAN2 the two representative use cases concluded in RAN1 for further study;
* Ask RAN2 for input about Uu interface error budget for each of the two use cases;

Agreements:

The following options for propagation delay compensation are further studied in RAN1

* **Option 1**: TA-based propagation delay
	+ **Option 1a**: Propagation delay estimation based on legacy Timing advance (potentially with enhanced TA indication granularity).
	+ **Option 1b**: Propagation delay estimation based on timing advanced enhanced for time synchronization (as 1a but with updated RAN4 requirements to TA adjustment error and Te)
	+ **Option 1c:** Propagation delay estimation based on a new dedicated signaling with finer delay compensation granularity (Separated signaling from TA so that TA procedure is not affected)
* **Option 2**: RTT based delay compensation:
	+ Propagation delay estimation based on an RAN managed Rx-Tx procedure intended for time synchronization (FFS to expand or separate procedure/signaling to positioning).

Draft LS R1-2007445 is approved, with final LS in R1-2007446.

**RAN1#103-e**

Agreements:

* Take 65 ns as the assumption of transmit timing error for evaluation of the overall time synchronization error for control-to-control.
* Asymmetry between downlink and uplink channel for smart grid scenario is not considered.
* ~~TA adjustment accuracy is not considered for the evaluation of time synchronization error.~~
* *errorBS,DL,TX* is included in the equation for calculating the overall time synchronization error.

Agreements:

TA adjustment accuracy is not considered for the evaluation of time synchronization error.

Agreements:

For evaluation of the overall time synchronization error for smart grid, companies can take one of the following two options as the assumption for BS transmit timing error:

* Option 1: 200 ns
* Option 2: 65 ns

**RAN1#104-e**

Agreements:Take ±100 ns as the assumption for downlink frame timing detection error (errorUE,DL,RX) at the UE for evaluation of the overall time synchronization error for TA based propagation delay compensation, if downlink frame timing detection error needs to be considered separately.

* Send a LS to RAN4 to ask for clarification on whether downlink frame timing detection error is included in Te or not
	+ In the LS, to include more details about option 1 (included) & option 2 (not included); also including the necessary background
* FFS whether to apply the same value to RTT-based propagation delay compensation, and the corresponding condition (if any) if the same value will be applied

**Decision:** As per email posted on feb 5th, the draft LS is endorsed. Final LS is approved in [R1-2102245](file:///C%3A%5CUsers%5Cc00387628%5CAppData%5CLocal%5CTemp%5CDocs%5CR1-2102245.zip).

**RAN1#104b-e**

Agreements:If downlink frame timing detection error needs to be considered separately from propagation delay estimation error, take ±100 ns as the assumption for downlink frame timing detection error (errorUE,DL,RX) at the UE for evaluation of the overall time synchronization error for RTT based propagation delay compensation

Agreements: Take the following equation for evaluation of the DL propagation delay estimation error for TA based propagation delay compensation:



* Either option 1 or option 2 below will be applied based on the RAN4 reply to RAN1 LS [R1-2102245](file:///C%3A%5CUsers%5Cc00387628%5CAppData%5CLocal%5CTemp%5CDocs%5CR1-2102245.zip).



* FFS whether *errorBS,DL,TX* in the above equation should be included or not.

Agreements:

* Observation 1: Propagation delay compensation based on existing Rel-15/Rel-16 TA procedure and associated granularity, with no enhancements in RAN1, is sufficient for meeting the Uu interface synchronicity error budget in LS R2-2010837 for the smart grid scenario.
* Observation 2: RAN1 needs to further study and specify the feasible enhancement (if any with RAN1 spec impact) for propagation delay compensation for control-to-control scenario, in order to meet the synchronicity budget of Uu interface in LS R2-2010837.

Working assumption:



Agreement:

Take the following as the evaluation assumptions for both RTT-based PDC and TA-based PDC.

* The UE may acquire an up-to-date PD estimation after waking up from DRX. This implies that gNB may signal an update timing advance value or complete a Rx-Tx measurement procedure.
* *errorUE,DL,RX* is based on other signals (e.g. CSI-RS) instead of SSB.
* *errorBS, UL,RX* iss based on other uplink signals instead of contention based PRACH, e.g. SRS.
* Further study and specify new procedure/signaling (if necessary) to ensure that the PD estimation can be acquired after DRX for the adopted PDC method.

Agreement:

Existing DL reference signal(s) are used for Rx – Tx time difference estimation at UE side for RTT-based propagation delay compensation, if RTT-based propagation delay compensation is supported.

* FFS whether PRS can be used for UE Rx – Tx time difference estimation or not
* FFS which DL reference signal(s) to be used if/when PRS is not used

**Conclusion:**

* Leave it to RAN2 to decide whether to support UE based compensation and/or gNB based compensation for any propagation delay compensation method RAN1 may adopt for Rel-17, if applicable.