3GPP TSG RAN WG1 #110bis-e R1-220839x

e-Meeting, October 10th – 19th, 2022

Agenda Item: 9.11.2

Source: Moderator (Thales)

Title: FL Summary #3: Network verified UE location for NR NTN

Document for: Discussion

# Introduction

This feature lead summary document aims to collect and align on company views on the issues related Network verified UE location in NR NTN. It contains a summary of the contributions under 9.11.2 at TSG-RAN WG1 #110-bis. together with identified key issues. The goal of this document is also to provide recommendation on prioritization of discussion and whether any issues should be postponed.

The source contributions are cited in references [4]-[23]: A total of 20 TDocs have been submitted to current meeting for discussion. Please see the Appendix for the details, with all the proposals.

RAN1 agreements on Network verified UE location for NR NTN made at RAN1 Meeting #110 could be found in section 13.

Please note the following checkpoints for agreements:

|  |
| --- |
| [110bis-e-R18-NTN-02] Email discussion on network verified UE location for NR NTN by October 19 – Mohamed (THALES)   * Check points: October 14, October 19 |

# Topic#1 Evaluation of Multi-RTT positioning method for Network verified UE location with single satellite

## Background

The following sub-sections aim at summarizing the different observations made in the contributions submitted to the RAN1#110bis with respect to Multi-RTT positioning method for Network verified UE location in NTN and provide high level tracks for the summary of evaluation results as well as the main technical aspects discussed by different companies.

## Companies’ contributions summary

The following views/observations were expressed with respect to Multi-RTT positioning method for Network verified UE location in NTN :

|  |  |
| --- | --- |
| **Companies** | **Proposals** |
| THALES | Observation 4. With multi-RTT based positioning method in case of a single satellite in view, UE position uncertainty area below 10km could be obtained only with low RTT errors (e.g. 50ns to 100ns) and longer duration for RTT measurements collection (e.g. 508s or 624s).  Observation 5. The time period required to calculate uplink multi-RTT measurement is excessively long in case of multi-RTT based positioning method is used with single satellite in view which makes the feasibility of the method questionable. |
| Huawei, HiSilicon | **Observation 4:** Multi-RTT positioning outperforms DL-TDOA positioning, and its performance improves with increment of time interval between two measurements.  **Observation 5**: With Multi-RTT positioning, the positioning accuracy of less than 10km @90% UEs can be achieved by 3 RTT measurements with time intervals of 6s (which corresponds to a latency of 18seconds) or 4 RTT measurements with time interval of 4s (which corresponds to a latency of 16seconds). |
| ZTE | **Observation 3:** Multi-RTT has better performance than UL/DL-TDOA method.  **Observation 4:** When the ambiguity of single satellite positioning is not considered or can be resolved by other methods, and the measurement period is equal to or larger than 30s, the positioning error of multi-RTT method can be smaller than 10km with over 95% probability for LEO-600 set-1, rural LOS, S-band scenario, earth fixed beam.  **Observation 5:** When the ambiguity of single satellite positioning is not considered, and the measurement period is equal to 30s, the positioning error of multi-RTT method can be smaller than 10km with over 90% probability for LEO-600 set-1, rural LOS, S-band scenario, earth fixed beam.  **Proposal 2:** Single-satellite based multi-RTT positioning method can be used for UE location verification for earth fixed beam in LEO.  **Observation 6:** For earth moving beam case, single-satellite based multi-RTT/UL-TDOA/DL-TDOA with angular information at gNB side cannot achieve target performance.  **Proposal 3:** The earth moving beam case is deprioritized for single satellite based location verification. |
| OPPO | **Observation 2:** For multi-RTT method, when UE position approaches the orbit plane, there exists an estimation handicap zone, where the positioning accuracy is remarkably impacted and this issue cannot be resolved by increasing the satellite time instance interval.  **Observation 3:** For multi-RTT method, there exisits a compromise between the coverage and positioning accuracy. |
| CATT | **Observation 2**: For the Multi-RTT method, the influence of satellite motion on the RTT measurements should be considered, and the UL timing measurement is always worse than the one of DL.  **Proposal 1:** The DL-OTDOA method with perfect time synchronization should be treated as the baseline, due to the less impaction in satellite rapid motion and SNR deterioration in UL compared with Multi-RTT method. |
| Intel | **Proposal 3**:   * For Multi-RTT positioning with single satellite, RX-Tx Time difference reported by the UE shall consider the autonomous TA applied by the UE |
| Lenovo | **Proposal 4:** RAN1 to further study DL-TDoA/UL-TDoA and Multi-RTT timing-based positioning techniques and associated adaptations for NTN to verify UE reported location  **Proposal 5:** For NTN network, UE position is determined based on the propagation delay differences between satellite(s) and UE.  **Proposal 6:** For NTN network, satellite positions for different time instances are useful to determine the propagation delay difference between satellite and UE. |
| Apple | **Proposal 7:** In NGSO scenario with multi-RTT positioning method, consider that the distance between satellite and UE at the time of downlink transmission is different from the distance between satellite and UE at the time of uplink transmission.  **Proposal 8:** In NGSO scenario with multi-RTT positioning method, do not support the scheme that RTT is obtained as the sum of UE reported total TA and the timing error of the uplink reference signal |
| Samsung | **Observation 1:** The ambiguity of the mirror image position cannot be resolved using RTT or any other time based RAT dependent method.  **Proposal 1:** The ambiguity of the mirror image position is resolved by very low resolution DL-PRS beamforming or UL angle of arrival determination.  **Proposal 2:** Study low resolution DL-PRS and low resolution UL angle of arrival determination to decide which one offers a more efficient solution for the ambiguity of the mirror image position.  **Proposal 3:** Single-satellite multi-RTT positioning method can be used for UE location verification for LEO constellation. The RTT measurements are performed by the same satellite at different time instances. |
| NTT DOCOMO | **Proposal 5:**  For multi-RTT positioning method, using UE/gNB Rx-Tx time difference measurements is baseline. |
| Qualcomm | **Observation 1:** Single satellite can be used to verify the UE location only if the satellite moves fast enough, e.g., a LEO satellite.  **Observation 3:** It is feasible to achieve verification accuracy of 5 to 10 km with both single and multiple satellites.   * For single satellite with RTT measurements, a measurement window up to a few seconds may be required.   **Proposal 3**: For network verification of UE location, consider the following methods:   * Multi-RTT for single NGSO satellites * DL TDOA with possible RTT for the serving satellite for multi-satellite case. |
| Nokia, Nokia Shanghai Bell | **Observation 1:** Methods like multi-RTT, UL/DL-TDOA alone cannot distinguish between the mirror positions on either side of the orbital plane.  **Proposal 2:** RAN1 to consider other measurement approaches than current standardized methods (e.g., Multi-RTT and DL/UL-TDOA) to solve the network verified UE position problem.  **Observation 2:** UE neighboring cells measurements can be a good indicator of the UE location relative to the orbital line.  **Proposal 3:** RAN1 to consider to combine UE neighbor measurements to solve the ambiguity between mirror points. |
| Panasonic | **Observation 1:** Multi-RTT with a set of equations adjusted to the NTN-environment is a viable method to determine UE location with a verification accuracy of 5 to 10 km and with a single satellite.  **Proposal 1:** Adopt Multi-RTT as a method for network-based UE location verification.  **Observation 2:** A measurement window in the order of seconds may be required to achieve the required accuracy.  **Observation 3:** Multi-RTT can be modified such that three measurements (instead of four) are sufficient to determine UE location in three dimensions, but this requires a sufficiently large interval between subsequent RTT-measurement.  **Observation 4**: The interval between RTT-measurements has a stronger impact on the accuracy of UE location estimation than the number of RTT-measurements.  **Proposal 2**: RAN1 should carefully consider the number of required RTT-measurements for multi-RTT. |
| LG Electronics | **Proposal #3:** If multi-RTT is selected as a baseline scheme for NW verified UE location, study at least followings  • How to handle timing error/delay due to processing time in satellite and movement of satellite and/or UE  • Configuration of DL-PRS and SRS for the multiple measurement of UE Rx-Tx time difference |

## Summary of Multi-RTT positioning method evaluation

Seven companies commented on the suitability of Multi-RTT positioning method for Network verified UE location in NTN:

For network verified UE location with single satellite based on multi-RTT positioning method:

* 5 sources observed that multi-RTT positioning method can meet the NTN UE location verification accuracy requirement for LEO:
  + 3 sources observed that the positioning accuracy of less than 10km can be achieved with few seconds latency (less or equal to 10s).
  + One source observed that the positioning accuracy of less than 10km can be achieved with 18 seconds latency.
  + One source observed that the positioning accuracy of less than 10km can be achieved with 30 seconds latency for earth fixed beam.
* One source observed that the positioning accuracy of less than 10km can be achieved only with 508 seconds latency, especially for UE near the orbit plane
* One source observed that the Multi-RTT method is more suitable for UE location far from the orbit plane

A recap of multi-RTT positioning method evaluation results is provided within the following table:

|  |  |
| --- | --- |
|  | Latency (seconds) |
| **[Thales]:** UE position uncertainty area below 10km could be obtained only with low RTT errors (e.g. 50ns to 100ns) and longer duration for RTT measurements collection (e.g. 508s or 624s). | **508** |
| **[Huawei, HiSilicon]:** With Multi-RTT positioning, the positioning accuracy of less than 10km @90% UEs can be achieved | **18 12** |
| **[ZTE]:** Single-satellite based multi-RTT positioning method can be used for UE location verification for earth fixed beam in LEO: The positioning error of multi-RTT method can be smaller than 10km with over 95% probability for LEO-600 set-1, rural LOS, S-band scenario, earth fixed beam.  For earth moving beam case, single-satellite based multi-RTT/UL-TDOA/DL-TDOA with angular information at gNB side cannot achieve target performance | **30 90** (earth fixed beam) |
| **[Oppo]:** ForUEs close to the orbit plane, there may exist some positioning estimation handicap zone, where the estimation accuracy may be remarkably impacted. and this issue cannot be resolved by increasing the satellite time instance interval | Even with 30s the raised near-orbit-plane issue subsist |
| **[Samsung]:** The accuracy of the RTT method will be satisfactory for the network verified requirements demanded by TR 38.882, even for the windows of measurement as short as 10s, and measurement errors as large as 200ns. | 10s |
| **[Qualcomm]:** It is feasible to achieve verification accuracy of 5 to 10 km with both single and multiple satellites.  • For single satellite with RTT measurements, a measurement window up to a few seconds may be required. | 8s |
| **[Panasonic]:** Multi-RTT with a set of equations adjusted to the NTN-environment is a viable method to determine UE location with a verification accuracy of 5 to 10 km and with a single satellite. | order of seconds |

## First round proposal 1

Based on the summary of Multi-RTT positioning method evaluation given in the section above it seems that there are two issues that might impact the feasibility of this method:

* The latency inherent to the method might be an issue (actually, it is an issue: to be discussed under Topic#4). Here, the latency is referring to the measurement window needed for RTT measurements collection.
* The second issue is related to measurement geometry which has an impact on location accuracy: indeed, The position error that results from RTT measurement errors depends on the relative geometry between the UE and the satellite positions. As observed by 4 sources multi-RTT method might not be appropriate for UE located near the orbit plane:
  + **Thales**: area near orbit plane has very high geometric dilution of precision (GDOP)
  + **Oppo**: Positioning estimation handicap zone; close to the orbit plane where the estimation accuracy may be remarkably impacted
  + **Qualcomm**: Figure 5 in [20]; black region corresponds to locations where max error is greater than 5km, which occur right below the satellite orbit.
  + **Nokia, Nokia Shanghai Bell**: one of the problems with triangulation methods is the general dilution of precision, which requires a relative large separation of the measurement point. With the approach of using only a single satellite, the measurement samples that are available will be located on a single line which is described by the satellite path during the fly-over. This reduction of the “space” when limiting to a single satellite monitoring will reduce the general accuracy.

Based on the above and from Moderator’s perspective, it is premature to conclude on the feasibility for this method and discuss design details (RTT determination, resolve ambiguity of the mirror image position etc…). We may first need more inputs on the acceptable latency for UE location verification (to be discussed in section 4). Further, companies may need more time to study the second issue related to **measurement geometry**.

Initial observation 1 is made as follows:

**Initial proposed observation 1:**

**For network verified UE location based on multi-RTT positioning method** **with single satellite:**

* **5 sources observed that multi-RTT positioning method can meet the NTN UE location verification accuracy requirement for LEO:**
  + **3 sources observed that the positioning accuracy of less than 10km can be achieved with few seconds latency (less or equal to 10s),**
  + **One source observed that the positioning accuracy of less than 10km can be achieved with 18 seconds latency,**
  + **One source observed that the positioning accuracy of less than 10km can be achieved with 30 seconds latency for earth fixed beam.**
* **One source observed that the positioning accuracy of less than 10km can be achieved only with 508 seconds latency, especially for UE near the orbit plane.**
* **One source observed that multi-RTT method is more suitable for UE location far from the orbit plane.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| QC | We need to specify a confidence level, for instance, 90-percentile. |
| Apple | Fine with the proposed observation. One clarification is needed. These observations are based on LEO-600, not LEO-1200. In general, different orbits will have different latencies. |
| Xiaomi | One clarification question is what is the intention or what’s the follow-ups with the observations. Meanwhile, the results are quite diverse at least from the latency aspects as different parameters like timing error, UE distribution are assumed in the evaluation. |
| Samsung | We are fine with the first bullet. However, for the second and the third bullets, the terms “near the orbit plane” and “far from the orbit plane” are not clear to us. Such terms as “far” and near the orbital plane” should be clarified and defined quantitatively to make them clearer. |
| vivo | Is the intention of this proposal to capture the observations in the TR? Or to have more detailed parameters so that companies can perform further evaluations and have comparable results in next RAN1 meeting? |
| Nokia, Nokia Shanghai Bell | We don't think that the proposed observation is correct, as using stand-alone multi-RTT will lead to 2 points/area's found, as stated in our contribution. The Multi-RTT will not be able to resolve the inherent ambiguity from pure time-based solutions. However, we do agree that multi-RTT may be part of the overall solution, if supplemented with other techniques (such as for instance AoA/AoD based techniques).  Further, we would like to highlight that 38.882 clearly states that the considered accuracy should be similar to terrestrial with examples of 5-10 km of accuracy. Hence, it would not be sufficient to meet the requirements of validation area for the largest value, but rather for the tighter requirement (5 km). |
| CATT | For the shown Multi-RTT results, we have two concerns:   1. not consider the Satellite movement in measurement duration 2. not consider the measurement error in the specific SNR range   Above factors will impact the validity of the measurement accuracy. |
| LG | Generally, observation is ok for us. Meanwhile, as commented by vivo and Xiaomi, what is the next step after this observation? |
| Lenovo | We agree with Samsung that it is not clear that what do the terms “near the orbit plane” and “far from the orbit plane” mean? It should be clearly defined. Moreover, the accuracy should be expressed in terms of percentiles for better understanding of the results. |
| OPPO | Fine |
| MediaTek | Fine with observation |
| NTT DOCOMO | We also wondering the intention of the observations. Some parameters like the measurement interval and timing errors which affect the positioning accuracy is not clear in the observation, and the latency may not be compared directly. |
| Ericsson | We don’t think it is necessary to agree on this. The reported results are already captured in the FL summary. |
| SONY | Is this a proposal to make a TR update? Given the range of results, it seems like no conclusion can be made at this stage. It is also not clear how the “2 points issue” is resolved (as per the NOK comment). |
| Huawei, HiSilicon | There are some mistakes in our calculation of latency in our contribution. See following, 3 RTT measurements have 3 measurements, but the latency should be 2\*6s=12s rather than 3\*6=18s. We will update our contribution which should be sent soon later.  ***Observation 5****: With Multi-RTT positioning, the positioning accuracy of less than 10km @90% UEs can be achieved by 3 RTT measurements with time intervals of 6s (which corresponds to a latency of 18seconds) or 4 RTT measurements with time interval of 4s (which corresponds to a latency of 16seconds).*  For the observed latency, we directly provide our values to 12s, considering we have also this smaller value to support the verification accuracy.   * + **One source observed that the positioning accuracy of less than 10km can be achieved with 1~~8~~2 seconds latency,**   We also have the similar question regarding the intention of this observation. |
| ZTE | We would like to correct the ZTE’s observation. In ZTE evaluation, the 30s refers to the measurement period. Since 4 measurements are used for positioning, the latency should be 30\*(4-1)=90s. That is, the first bullet may be updated as:   * **5 sources observed that multi-RTT positioning method can meet the NTN UE location verification accuracy requirement for LEO:**   + **3 sources observed that the positioning accuracy of less than 10km can be achieved with few seconds latency (less or equal to 10s),**   + **One source observed that the positioning accuracy of less than 10km can be achieved with 18 seconds latency,**   + **One source observed that the positioning accuracy of less than 10km can be achieved with 90 seconds latency for earth fixed beam.**   The latency is also related to the confidence level, which may need to be clarified when describing the observations.  Moreover, in our evaluation, 2D and 3D positioning methods will have different positioning error. In 3D positioning, the height uncertainty would cause larger positioning error, which will not happen in 2D positioning. Therefore, which positioning method is used should be clarified in the observation. And since UE height report cannot be assumed reliable (similar as GNSS, RAT-independent value), 3D positioning method should be applied instead of 2D positioning although 2D error is counted in performance evaluation. We think this issue should be clarified before further discussion on the positioning method. |

## Second round proposal 1

Different views were expressed during the first round of discussions:

As pointed out by [**Qualcomm, Lenovo**] confidence level is added to the updated proposal below.

Several companies have concern on the intention of the observation or what’s the follow-ups with the observations as requested by [**Xiaomi, vivo, LG** **NTT DOCOMO, SONY, Huawei, HiSilicon, Ericsson**]. Moderator’s feedback: There will be no dedicated TR but we need to capture all these observations as outcome of the study. It was decided in TSG-RAN that the study outcomes would be captured in the chair’s notes. As mentioned earlier, it is premature to conclude on the feasibility for the method for now. But we need to capture the results of the evaluations submitted in companies contribution to current meeting. If needed, these observations could be revisited in the next meeting (last meeting for the ongoing study). There are two lessons learnt from these observations:

1. Higher latency would be needed for UE location verification which might be an issue
2. As observed by two sources multi-RTT positioning method might not be suitable depending on the UE position with regard to anchor points used for the positioning (please refer to Oppo, Thales, Qualcomm and Nokia contributions)

The proposal is updated by considering comment from [**Samsung, Lenovo]** regardingnear/far the orbit plane” wording. Hopefully, new wording is more clear.

On the ambiguity of the mirror image position as mentioned by [**SONY, Nokia**], the text “ assuming the ambiguity of the mirror image position is resolved” is added.

Also, observations from **Huawei, HiSilicon and ZTE** were corrected based on their comments.

**Updated proposed observation 1:**

**For network verified UE location based on multi-RTT positioning method** **with single satellite, assuming the ambiguity of the mirror image position is resolved:**

* **5 sources observed that multi-RTT positioning method can meet the NTN UE location verification accuracy requirement for LEO 600km with 95-percentile confidence level:**
  + **3 sources observed that the positioning accuracy of less than 10km can be achieved with few seconds latency (less or equal to 10s)**
  + **One source observed that the positioning accuracy of less than 10km can be achieved with 12 seconds latency**
  + **One source observed that the positioning accuracy of less than 10km can be achieved with 90 seconds latency for earth fixed beam.**
* **Two sources observed that multi-RTT positioning method might not be suitable depending on the UE position with regard to anchor points used for the positioning:**
  + **One source observed that the measurement geometry has an impact on the achievable accuracy: The positioning accuracy of less than 10km can be achieved only with 508 seconds latency, especially for UE near the orbit plane.**
  + **One source observed that multi-RTT method is more suitable for UE location far from the orbit plane: Even with 30s latency the near-orbit-plane issue subsist.**

**Note-1: For observation above different timing measurement errors were considered by companies.**

**Note-2: Error due the satellite movement between TX and RX measurements is not takin into account**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| Panasonic | We are fine to capture these observations. But RAN1 should attempt to explain the large span of results, i.e., from feasible within a few seconds up to impossible. | |
| Lenovo | We are fine the proposed observations |
| Apple | We think Note-2 should be put to the top of the proposal. When considering satellite movement between TX and RX measurements, it is not sure the positioning accuracy of less than 10 km can still be achieved within the reported latency.    **For network verified UE location based on multi-RTT positioning method** **with single satellite, assuming the ambiguity of the mirror image position is resolved and error due the satellite movement between TX and RX measurements is not taken into account:** |
| Nokia, Nokia Shanghai Bell | The updated proposal is better in line with our understanding, as the potential aspect of mirror points/areas is captured.  However, the aspect of the observations from TR 38.882 does not seem to be captured correctly, since there is it clearly stated that the considered accuracy should be similar to terrestrial with examples of 5-10 km of accuracy. Hence, it would not be sufficient to meet the requirements of validation area for the largest value, but rather for the tighter requirement (5 km). None of the presented results are considering the 5 km as accuracy threshold, so it would be **incorrect** to capture that “**multi-RTT positioning method can meet the NTN UE location verification accuracy requirement for LEO**” |
| Samsung | We strongly agree with the added text “assuming the ambiguity of the mirror image position is resolved”.  However, we still have concerns about the definitions of “near and far orbit-plane.” Actually, for the last two observations, it seems that each observation is saying the exact oppose thing. Thus, before making the observation, it should be clarified first on their observations in detail, for example, what is main difference assumption between them. If it is not clearly clarified, it is likely to make wrong conclusion. |
| LG | We are fine with revision by Apple. |
| ZTE | Basically fine. But again, we would like to show our concern on the 2D/3D positioning methods. RAN1 has achieved consensus that 2D error is used in performance evaluation. But there is no agreement that UE height is known by network, so that 3D positioning method should be applied instead of 2D positioning method. Considering different assumptions on the knowledge of UE height may be assumed, which can lead to significantly varied evaluation results, we suggest to add following note in the proposal:  **Note-3: 2D and 3D positioning methods should be distinguished in further discussion and conclusion**  Or we directly take 3D positioning in the assumption. |
| vivo | We don’t agree with the proposal.  Different companies have different assumptions, the proposal doesn’t take the difference into account.  So, it would be good to consider the detailed assumptions as well.  Is the intention to reject the method as long as it cannot meet the requirement with **some** assumptions? |
| SONY | We prefer the updated proposal to the initial version.  There is a large variation in results. Maybe we should try to align evaluation / simulation assumptions to reduce the variation.  We do not agree with Nokia that a 5km accuracy requirement needs to be achieved. Our understanding of “5km – 10km” is that the accuracy needs to be in the ball park of the size of a town – it doesn’t mean that the accuracy needs to be 5km. It means the accuracy should be better than 10km.  We think that 3D positioning is unnecessary. We only need to verify the x-y location of the UE. |
| Huawei, HiSilicon | Based on the discussion, we are wondering it is premature to draw observations considering the results diverged a lot and following aspects have not been aligned. Can we align the following assumptions in this meeting.  - align the assumption on timing measurement errors  - agree that error due the satellite movement between TX and RX measurements should be considered the evaluation results in the next meeting  By the way, our observation is based on 90%-tile UE. |

## Third round proposal 1

The updated proposal 1 is modified to capture second round companies comments as much as possible.

The answer to the question from Nokia, Nokia Shanghai Bell on 5km accuracy requirement is given by Sony. Moderator shares the same view as Sony.

To Samsung, the last two observations are about the measurement geometry aspects that should be considered. Indeed, depending on the relative position of the UE and the vTRPs (satellite anchor points used for the RTT measurements) the positioning accuracy cannot be achieved: one source observed that the arrangement of the satellite positions on the orbit (satellite geometry and how vTRPs are spread) affects the accuracy of the positioning. Thus very large measurements period would be needed (508s latency). For the other source, even with 30s latency the near-orbit-plane issue subsist.

To vivo: Could you please provide the detailed assumptions that should be considered/captured with this proposed observation?. To moderator understanding the notes added (in red) are enough. Of course, the group will revisit (if needed) these observations in upcoming meeting.

ZTE raised concern on the 2D/3D positioning methods. The note 2 is added.

To vivo, Huawei, HiSilicon: the note 3 is added, hopefully this answers the raised concerns.

The proposed observation 1 is updated based on the above discussion:

**3rd round proposed observation 1:**

**For network verified UE location based on multi-RTT positioning method** **with single satellite, assuming the ambiguity of the mirror image position is resolved and error due the satellite movement between TX and RX measurements is not taken into account:**

* **5 sources observed that multi-RTT positioning method can meet the NTN UE location verification accuracy requirement for LEO 600km:**
  + **3 sources observed that the positioning accuracy of less than 10km can be achieved with few seconds latency (less or equal to 10s) with 95-percentile confidence level**
  + **One source observed that the positioning accuracy of less than 10km can be achieved with 12 seconds latency with 90-percentile confidence level**
  + **One source observed that the positioning accuracy of less than 10km can be achieved with 90 seconds latency for earth fixed beam with 95-percentile confidence level**
* **Two sources observed that multi-RTT positioning method might not be suitable depending on the UE position with regard to anchor points used for the positioning:**
  + **One source observed that the measurement geometry has an impact on the achievable accuracy: The positioning accuracy of less than 10km can be achieved only with 508 seconds latency, especially for UE near the orbit plane.**
  + **One source observed that multi-RTT method is more suitable for UE location far from the orbit plane: Even with 30s latency the near-orbit-plane issue subsist.**

**Note-1: For observation above different timing measurement errors were considered by companies.**

**Note-2: 2D and 3D positioning methods should be distinguished in further discussion and conclusion.**

**Note 3: RAN1 will revisit/update the above observation in RAN1#111 meeting by considering further evaluation results taking into account error due the satellite movement between TX and RX measurements and aligned assumption on timing measurement errors.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| Apple | Agree |
| Samsung | Agree |
| LG | We don’t think Note-2 is necessary as we agreed on the 2D positioning in RAN1#110. Or we can directly say, “For observation above, Horizontal accuracy is assumed by companied.” |
| ZTE | OK with the proposal. In RAN1#110, RAN1 only agree to use 2D accuracy for performance evaluation. But 3D or 2D positioning is used is unclear. And 3D positioning methods should be considered by default since UE height is not guaranteed to be known by network. |

# Topic#2 Evaluation of XL-TDOA method for Network verified UE location in NTN

## Background

The following sub-sections aim at summarizing the different observations made in the contributions submitted to the RAN1#110bis with respect to UL/DL-TDOA positioning method for Network verified UE location in NTN and provide high level tracks for the summary of evaluation results as well as the main technical aspects discussed by different companies.

## Companies’ contributions summary

The following views/observations were expressed with respect to XL-TDOA positioning method for Network verified UE location in NTN :

|  |  |
| --- | --- |
| **Companies** | **Proposals** |
| Huawei | **Observation 1:** With DL-TDOA positioning, the horizontal error decreases with the increasing of the time interval and the number of measurements.  **Observation 2:** With DL-TDOA positioning, the positioning accuracy of less than 10km @90% UEs can be achieved under the time interval of 8s with 3 RSTDs (which corresponds to a latency of 32 seconds) or 6s with 4 RSTDs (which corresponds to a latency of 30 seconds).  **Observation 3:** UL-TDOA positioning is not suitable in verification of UE reported location due to the open-loop TA update on UE, meanwhile even if the pre-compensated TA is fixed on UE in order to enable UL-TDOA based location verification, the remaining TA of UE could exceed the CP length and lead to timing misalignment in uplink transmissions. |
| vivo | **Observation1:**   * The maximum timing measurement error allowed to meet the positioning accuracy requirement of 5-10km is about 100ns when the measurement gap is 30s.   **Observation2:**   * The maximum timing measurement error allowed to meet the positioning accuracy requirement of 5-10km is about 200ns when the measurement gap is 60s.   **Observation3:**   * The maximum timing measurement error allowed to meet the positioning accuracy requirement of 5-10km is about 300ns when the measurement gap is 120s.   **Observation4:**   * The larger the measurement gap is configured, the larger the additional timing measurement error can be allowed to meet the target positioning accuracy.   **Proposal 1:**   * Reuse existing DL-TDoA method already specified in TN which is enough for UE location verification in NTN. |
| Oppo | **Observation 4:** for DL-TDOA method, the issue for UE approaching the orbit plane also exists but this issue can be resolved by enlarging the satellite time instance interval.  **Observation 5:** DL-TDOA method can meet the NTN UE location verification accuracy requirement with agreed simulation assumptions.  **Proposal 2:** RAN1 to take DL-TDOA as a baseline method with higher priority. |
| CATT | **Proposal 1:** The DL-OTDOA method with perfect time synchronization should be treated as the baseline, due to the less impaction in satellite rapid motion and SNR deterioration in UL compared with Multi-RTT method.  **Observation 3:** Due to the impact of SNR, the higher elevation angles the UE begins measuring, the better performance can be achieved in horizontal position error.  **Proposal 5:** In LEO 600km scenario, the horizon position error can be achieved less than 10km above 97% by collecting 10 measurements in about 180s when the UE’s elevation angle is above 30º.  **Proposal 6:** In LEO 1200km scenario, the horizon position error can be achieved less than 7km above 100% by collecting 15 measurements in about 280s with the elevation angle beginning at 30º, meanwhile the total measuring time reduced to 120s with collecting 7 measurements to satisfy the accuracy when the elevation angle beginning with 60º. |
| Intel | **Proposal 1**:  The following enhancements are considered to enable UL-TDOA for single satellite-based positioning   * Reporting of the TA values applied for each SRS transmission * Reporting of the TA value applied for the 1st SRS transmission and fixed TA for other SRS transmissions.   **Proposal 2**:  The following enhancement is considered for DL-TDOA for single satellite-based positioning   * Reporting of RSTD values for multiple measurements of single PRS resource (periodic or semi-persistent) with a PRS transmission for the same PRS resource as a time reference |
| Xiaomi | **Observation:**   * The measurement interval, and the satellite orbit have significant impact on the positioning accuracy * The delay for verifying the location is at least 10s and 20s for LEO600 and LEO1200 cases respectively.   **Proposal 5:** The DL-TDOA solution is feasible to support the network verified location.  **Proposal 6:** The delay required for verifying the location needs to be further considered to avoid the impact to the service. |
| Apple | **Proposal 4:** For network verified UE location with DL TDOA positioning method, the LMF based scheme is used.  **Proposal 5:** For network verified UE location with DL TDOA positioning method, the time differences between multiple DL PRS transmission instances need to be reported from gNB to LMF.  **Proposal 6:** For network verified UE location with UL TDOA positioning method, the time differences between multiple UL SRS transmission instances need to be reported from UE to LMF. |
| Nokia, Nokia Shanghai Bell | **Observation 1:** Methods like multi-RTT, UL/DL-TDOA alone cannot distinguish between the mirror positions on either side of the orbital plane.  **Proposal 2:** RAN1 to consider other measurement approaches than current standardized methods (e.g., Multi-RTT and DL/UL-TDOA) to solve the network verified UE position problem |

## Summary of UL/DL-TDOA positioning method evaluation

Six companies provided inputs on the suitability of DL-TDOA positioning method for Network verified UE location in NTN:

For network verified UE location based on DL-TDOA positioning method with single satellite:

* Five sources observed that DL-TDOA positioning method can meet the NTN UE location verification accuracy requirement for LEO:
  + 2 sources observed that the positioning accuracy of less than 10km can be achieved with 20 seconds latency or less:
    - According to one of the two sources: the latency maybe reduced to 12s with 90% horizontal accuracy
    - For the other source: the latency is at least 10s and 20s for LEO600 and LEO1200 cases respectively.
  + One source observed that the positioning accuracy of less than 10km @90% UEs can be achieved with 32 seconds latency.
  + One source observed that the positioning accuracy of less than 10km can be achieved with 30, 60, 120 seconds latency with timing measurement errors of 100ns, 200ns and 300ns respectively.
  + One source observed that the positioning accuracy of less than 10km @97% UEs can be achieved with 180 (LEO600) and 280 (LEO1200) seconds latency.
* One source observed that DL-TDOA cannot meet the target requirement for both earth fixed beam and earth moving beam

A recap of DL-TDOA positioning method evaluation results is provided within the following table:

|  |  |
| --- | --- |
|  | Latency (seconds) |
| **[Huawei, HiSilicon]:** With DL-TDOA positioning, the positioning accuracy of less than 10km @90% UEs can be achieved | **32 24** |
| **[vivo]:** With proper measurement gap configuration, DL-TDoA method would be enough to meet the target positioning accuracy of 5 to 10km | **30** (with timing measurement error = 100ns), 60s (with timing measurement error = 200ns), 120s (with timing measurement error = 300ns), |
| **[ZTE]:** DL-TDOA cannot meet the target requirement **for both earth fixed beam and earth moving beam**  Positioning error performance for DL-TDOA without consideration of ambiguity issue = 29.93 km, CDF=95% | **60** (to achieve 29.93 km, CDF=95%) |
| **[OPPO]:** DL-TDOA method can meet the NTN UE location verification accuracy requirement with agreed simulation assumptions:  90% horizontal accuracy is below 8km and 95% horizontal accuracy is below 11.3km, with 12s latency  95% horizontal accuracy is below 5.6km, with 20s latency | **20** (maybereduced to 12s with 90%) |
| **[CATT]:** With DL-TDOA: in LEO 600km scenario, the horizon position error can be achieved less than 10km above 97% by collecting 10 measurements in about 180s when the UE’s elevation angle is above 30º. In LEO 1200km scenario, the horizon position error can be achieved less than 7km above 100% by collecting 15 measurements in about 280s with the elevation angle beginning at 30º | **180** (LEO600)  **280** (LEO1200) |
| **[Xiaomi]:** The DL-TDOA solution is feasible to support the network verified location  The delay for verifying the location is at least 10s and 20s for LEO600 and LEO1200 cases respectively | **10** (LEO600)  **20** (LEO1200) |

Two companies commented on the suitability of UL-TDOA positioning method for Network verified UE location in NTN:

For network verified UE location based on UL-TDOA positioning method with single satellite:

* One source observed that UL-TDOA cannot meet the target requirement due to the open-loop TA update on UE.
* The other source observed that UL-TDOA cannot meet the target requirement for both earth fixed beam and earth moving beam. This source highlighted that with 60s latency the positioning error performance that can be achieved is 43.46 km, CDF=90%.

A recap of UL-TDOA positioning method evaluation results is provided within the following table:

|  |  |
| --- | --- |
|  | Latency (seconds) |
| **[Huawei, HiSilicon]:** UL-TDOA positioning is not suitable in verification of UE reported location due to the open-loop TA update on UE |  |
| **[ZTE]:** UL-TDOA cannot meet the target requirement **for** **both earth fixed beam and earth moving beam**  Positioning error performance for UL-TDOA without consideration of ambiguity issue = 43.46 km, CDF=90% | **60s** (to achieve 43.46 km, CDF=90%) |

## First round proposal 2

Based on the summary of DL-TDOA positioning method evaluation given in the section above it seems that the latency issue might impact the feasibility for this method. The measurement geometry may have also an impact on location accuracy. **Also, how RSTD measurements are performed with single satellite and w.r.t to which reference need further discussions**.

Thereby, from Moderator’s perspective, it is premature to conclude on the feasibility of this method. We may need more inputs on the acceptable latency for UE location verification (to be discussed under section 4). Details design of DL-TDOA (RSTD measurements etc..) and potential enhancements to be considered to enable DL-TDOA in NTN could be discussed when the group conclude on the feasibility of the method.

Initial proposed observation 2 is made as follows:

**Initial proposed observation 2:**

**Six companies provided inputs on the suitability of DL-TDOA positioning method for Network verified UE location with single satellite:**

* **Five sources observed that DL-TDOA positioning method can meet the NTN UE location verification accuracy requirement for LEO:**
  + **Two sources observed that the positioning accuracy of less than 10km can be achieved with 20 seconds or less:**
    - **According to one of the two sources: the latency maybe reduced to 12s with 90% horizontal accuracy**
    - **For the other source: the latency is at least 10s and 20s for LEO600 and LEO1200 cases respectively.**
  + **One source observed that the positioning accuracy of less than 10km @90% UEs can be achieved with 32 seconds latency.**
  + **One source observed that the positioning accuracy of less than 10km can be achieved with 30, 60, 120 seconds latency with timing measurement errors of 100ns, 200ns and 300ns respectively.**
  + **One source observed that the positioning accuracy of less than 10km @97% UEs can be achieved with 180 (LEO600) and 280 (LEO1200) seconds latency.**
* **One source observed that DL-TDOA cannot meet the target requirement for both earth fixed beam and earth moving beam.**

**Two companies commented on the suitability of UL-TDOA positioning method for Network verified UE location with single satellite:**

* **One source observed that UL-TDOA cannot meet the target requirement due to the open-loop TA update on UE**
* **Another source observed that UL-TDOA cannot meet the target requirement for both earth fixed beam and earth moving beam. With 60s latency positioning error performance that can be achieved is 43.46 km, CDF=90%.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| QC | For DL-TDOA for single satellite, the biggest error would be UE clock accuracy. New simulations are needed by taking into account UE clock accuracy before any observation s can be made. |
| Apple | Fine with the proposed observation. |
| Xiaomi | One clarification question is what is the intention or what’s the follow-ups with the observations. Meanwhile, the results are quite diverse at least from the latency aspects as different parameters like timing error, UE distribution are assumed in the evaluation. |
| Samsung | We would like to suggest two main bullets as follows.  **For network verified UE location based on DL-TDOA positioning method** **with single satellite,**  …  **For network verified UE location based on UL-TDOA positioning method** **with single satellite,** |
| vivo | Following description is not accurate since they have different assumptions as other companies, e.g. 95% is too high and not a typical CDF point used in positioning evaluations, only 60s measurement gap is assumed, SNR value of 30 degree is assumed for all the 4 measurements which is not true for some of the measurements. At least these assumptions should be included for this observation.  -“**One source observed that DL-TDOA cannot meet the target requirement for both earth fixed beam and earth moving beam.**”  In addition, we do not think we should consider latency as a problem for network to verify UE location which does not have to be so frequent.  Note that in our evaluation, even when we assume up to 300ns additional timing error, with larger measurement gap, the DL-TDoA method can make sure of a positioning accuracy with in 10km.  Therefore, we would prefer to conclude that DL-TDoA is enough to verify UE location with proper measurement gap configured. |
| Nokia, Nokia Shanghai Bell | We don't think that the proposed observation is correct, as using stand-alone UL-TDOA will lead to 2 points/area's found, as stated in our contribution. As stated for initial proposed observation 1, there is a lack of ability to resolve the inherent ambiguity from pure time-based solutions.  One further aspect is that to our understanding, any TDOA based solution will have to reset whenever timing advance is updated, which is expected to happen frequently due to the high change rate of the service link and feeder link conditions.  Further, we would like to highlight that 38.882 clearly states that the considered accuracy should be similar to terrestrial with examples of 5-10 km of accuracy. Hence, it would not be sufficient to meet the requirements of validation area for the largest value, but rather for the tighter requirement (5 km). |
| CATT | Since the results are quite diverse, it is necessary to align the measurement error model and calculation algorithm.  For UL-TDOA, the lower SNR will impact the position accuracy, but this issue has not been taken into account in shown results. |
| LG | Same question as in proposal 1. |
| Lenovo | Ok with the observations |
| Intel | For the UL-TDOA observation we prefer to clarify that existing UL-TDOA without enhancements for NTN is assumed for the first sub-bullet as follows:  **One source observed that UL-TDOA cannot meet the target requirement due to the open-loop TA update on UE assuming existing UL-TDOA method without NTN-specific enhancements** |
| OPPO | For the one source observed that DL-TDOA cannot meet the target requirement. We didn’t see the source providing simulation results to prove that the requirement cannot met. Thus, we suggest to remove this observation.  For the following observation:   * + **One source observed that the positioning accuracy of less than 10km can be achieved with 30, 60, 120 seconds latency with timing measurement errors of 100ns, 200ns and 300ns respectively.**   We suggst a rewording to make it clear that the timing measurement error is an assumption by the source company instead of a simulated actual measurement error.   * + **One source observed that the positioning accuracy of less than 10km can be achieved with 30, 60, 120 seconds latency with timing measurement errors of 100ns, 200ns and 300ns respectively, where the timing measurement errors are assumed instead of simulated errors.** |
| MediaTek | DL-OTDOA should take into account clock accuracy impact on timing error. The UE implementation will need to track the DL synchronization parameter and correct timing for the internal clock and at the same time estimate the UE-serving satellite delay at different times for single satellite scenario. |
| NTT DOCOMO | Generally okay, same comment as proposal 1. |
| Ericsson | We don’t think it is necessary to agree on this. The reported results are already captured in the FL summary. |
| SONY | Similar comment as for Issue#1:  Is this a proposal to make a TR update? Given the range of results, it seems like no conclusion can be made at this stage. It is also not clear how the “2 points issue” is resolved (as per the NOK comment). |
| Huawei, HiSilicon | There are some mistakes in our calculation of latency in our contribution. See following, 3 RSTDs have 4 measurements, but the latency should be 3\*8s=24s rather than 4\*8=32s. We will update our contribution which should be sent soon later.  ***Observation 2:*** *With DL-TDOA positioning, the positioning accuracy of less than 10km @90% UEs can be achieved under the time interval of 8s with 3 RSTDs (which corresponds to a latency of 32 seconds) or 6s with 4 RSTDs (which corresponds to a latency of 30 seconds).*  Therefore, we correct our results to 24seconds here.  The intention of the observation seems not clear, considering the assessment from moderator. |
| ZTE | Similar as proposal 1, 2D and 3D positioning methods will have different positioning error. In 3D positioning, the height uncertainty would cause larger positioning error, which will not happen in 2D positioning. And in TDOA method this phenomenon is especially significant. Therefore, which positioning method is used should be clarified in the observation. And since UE height report cannot be assumed reliable (similar as GNSS, RAT-independent value), 3D positioning method should be applied instead of 2D positioning although 2D error is counted in performance evaluation. We think this issue should be clarified before further discussion on the positioning method. |

## Second round proposal 2

Many companies commented on Initial Proposal 2 at the first round of discussions.

On the intention of the proposed observation as raised by [**Xiaomi, LG, Ericsson, SONY, Huawei, HiSilicon**]: please refer to section 1.5.

To [**Vivo**] : from Moderator’s perspective, it is premature to conclude on the feasibility of DL-TDOA. The latency might be an issue. It is not true that the UE location verification does not have to be so frequent. At last there is no agreement on that or no input from other WGs. At least by considering the fact that SA3-LI has established the requirement that "any solution shall support the ability to enforce the use of a Core Network of PLMN in the country where the UE is physically located” it might be necessary to trigger the verification procedure frequently.

Regarding the concern from [**Nokia, Nokia Shanghai Bell, SONY**] the text “ assuming the ambiguity of the mirror image position is resolved” is added.

Further, regarding Nokia’s comment on the positioning accuracy: To the moderator understanding, it is enough if the positioning accuracy of less than 10km is satisfied (this is typical TN cell coverage area) And enough the satisfy resolve the resolve the issues raised in the WID. Anyway, the observation it is clearly mentioned that the evaluation results are about the positioning accuracy of less than 10km.

Based on [**Qualcomm, MediaTek**] feedback: a note is added reading Error due to UE clock accuracy.

The proposal is updated as follows:

**Updated proposed observation 2:**

**For network verified UE location based on DL-TDOA positioning method with single satellite, assuming the ambiguity of the mirror image position is resolved:**

**Six companies provided inputs on the suitability of the method:**

* **Five sources observed that DL-TDOA positioning method can meet the NTN UE location verification accuracy requirement for LEO:**
  + **Two sources observed that the positioning accuracy of less than 10km can be achieved with 20 seconds or less:**
    - **According to one of the two sources: the latency maybe reduced to 12s with 90% horizontal accuracy**
    - **For the other source: the latency is at least 10s and 20s for LEO600 and LEO1200 cases respectively.**
  + **One source observed that the positioning accuracy of less than 10km @90% UEs can be achieved with 24 seconds latency.**
  + **One source observed that the positioning accuracy of less than 10km can be achieved with 30, 60, 120 seconds latency with timing measurement errors of 100ns, 200ns and 300ns respectively where the timing measurement errors are assumed instead of simulated errors.**
  + **One source observed that the positioning accuracy of less than 10km @97% UEs can be achieved with 180 (LEO600) and 280 (LEO1200) seconds latency.**
* **One source observed that DL-TDOA cannot meet the target requirement for both earth fixed beam and earth moving beam.**

**For network verified UE location based on UL-TDOA positioning method** **with single satellite, assuming the ambiguity of the mirror image position is resolved:**

**Two companies commented on the suitability of the method:**

* **One source observed that UL-TDOA cannot meet the target requirement due to the open-loop TA update on UE**
  + **Note: This observation is not based on simulation results to prove that the requirement cannot met**
* **Another source observed that UL-TDOA cannot meet the target requirement for both earth fixed beam and earth moving beam. With 60s latency positioning error performance that can be achieved is 43.46 km, CDF=90%.**

**Note: Error due to UE clock accuracy is not taken into account in the above observation. New simulations are needed by taking into account UE clock accuracy.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| OPPO | Support |
| CATT | Support |
| Lenovo | Support |
| Intel | As we commented in the previous round, the first observation for UL-TDOA is done based on the existing approach for TA update for SRS and TA reporting (basically, existing UL-TDOA method without NTN-specific enhancements).  So, we propose to add the following note for this observation.   * + **Note: This observation is based on existing UL-TDOA method without additional NTN-specific enhancements** |
| Apple | Fine with the proposed observation. |
| Nokia, Nokia Shanghai Bell | As we raised in the comment on the TDOA based methods potentially suffering from these methods having to reset every time the TA is updated, we would like to have explicit confirmation that the UE autonomous TA updates (including reset of the algorithm each time the UE applied autonomous TA was updated) were specifically modeled in the simulations. |
| Samsung | Fine with the observation. |
| LG | Fine with the observation. |
| ZTE | Basically fine. But again, we would like to show our concern on the 2D/3D positioning methods. RAN1 has achieved consensus that 2D error is used in performance evaluation. But there is no agreement that UE height is known by network, so that 3D positioning method should be applied instead of 2D positioning method. Considering different assumptions on the knowledge of UE height may be assumed, which can lead to significantly varied evaluation results, we suggest to add following note in the proposal:  **Note-3: 2D and 3D positioning methods should be distinguished in further discussion and conclusion**  Or we directly take 3D positioning in the assumption. |
| vivo | As we commented earlier, following description is not accurate since they have different assumptions as other companies, e.g. 95% is too high and not a typical CDF point used in positioning evaluations, only 60s measurement gap is assumed, SNR value of 30 degree is assumed for all the 4 measurements which is not true for some of the measurements. At least these assumptions should be included for this observation.  -“**One source observed that DL-TDOA cannot meet the target requirement for both earth fixed beam and earth moving beam.**”  So it would be good to consider the detailed assumptions as well.  Is the intention to reject the method as long as it cannot meet the requirement with **some** assumptions? |
| SONY | We think there are insufficient results to draw conclusions at this stage, especially for UL-TDOA.  The large variation in results could potentially be narrowed by aligning evaluation / simulation assumptions. As part of the alignment, we would like the following to be clarified:   * Use of earth-fixed vs earth-moving beams * UE clock accuracy assumptions * Potential sources of error other than UE clock accuracy   We understand that NTN enhancements could be applied to UL-TDOA, for example by reporting the TA applied with UL-TDOA reports. Referring to both the comments by Intel and Nokia, we agree that TA needs to be taken into account when using UL-TDOA with virtual TRPs. We think that taken TA reports into account is feasible. |
| Huawei, HiSilicon | There is quite big difference for the simulation results. We are not sure how RAN plenary can use this observation. Maybe some discussion and further alignment on simulation is needed among companies. |

## Third round proposal 2

To Nokia and Sony: The intention is not to draw conclusion at this stage. The observations are made based on preliminary evaluation results contributed to current meeting. The group will revisit these observations in next meeting. Note 5 is added.

To vivo: on the observation in second bullet: Assumptions considered are the same as other companies, please refer to R1-2208694:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| R1-2208694:  With the parameters listed in Table 10 and above assumptions, the performance of positioning error is evaluated for multi-RTT, UL-TDOA and DL-TDOA. Note that for timing measurement error, the SNR is assumed as the link budget calculated based on real elevation angle instead of that under 30 degree elevation angle. The simulation results without consideration of ambiguity issue in above paragraph are as listed in Table 1, Table 2, and Table 3. For TDOA method, it can be observed that DL-TDOA can achieve better performance than UL-TDOA due to higher link budget. However, since 3D TDOA method is less robust to the timing measurement error in single satellite case, DL-TDOA method will have worse performance compared with multi-RTT method even if it will have better SNR. The multi-RTT method can satisfy the accuracy requirement with 95% probability if the measurement period is longer than 30s when ambiguity issue is not considered.  ….  Table 2 Positioning error performance for UL-TDOA without consideration of ambiguity issue   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | CDF=50% | CDF=67% | CDF=80% | CDF=90% | CDF=95% | | δ=5s | 303.25 km | 436.97 km | 618.52 km | ~ | ~ | | δ=10s | 98.90 km | 158.01 km | 237.50 km | 399.69 km | 681.97 km | | δ=30s | 8.69 km | 16.91 km | 32.60 km | 75.97 km | 170.12 km | | δ=60s | 4.04 km | 8.69 km | 17.98 km | 43.46 km | 95.36 km |   Table 3 Positioning error performance for DL-TDOA without consideration of ambiguity issue   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | CDF=50% | CDF=67% | CDF=80% | CDF=90% | CDF=95% | | δ=5s | 186.54 km | 271.96 km | 389.67 km | 544.66 km | ~ | | δ=10s | 44.85 km | 73.59 km | 115.13 km | 194.79 km | 316.52 km | | δ=30s | 3.39 km | 6.73 km | 13.09 km | 28.29 km | 54.89 km | | δ=60s | 1.52 km | 3.34 km | 7.06 km | 15.31 km | 29.93 km |   The performance evaluation results with consideration of ambiguity issue are listed in Table 4, Table 5, |

The proposal is updated as follows:

**3rd round proposed observation 2:**

**For network verified UE location based on DL-TDOA positioning method with single satellite, assuming the ambiguity of the mirror image position is resolved:**

**Six companies provided inputs on the suitability of the method:**

* **Five sources observed that DL-TDOA positioning method can meet the NTN UE location verification accuracy requirement for LEO:**
  + **Two sources observed that the positioning accuracy of less than 10km can be achieved with 20 seconds or less:**
    - **According to one of the two sources: the latency maybe reduced to 12s with 90% horizontal accuracy**
    - **For the other source: the latency is at least 10s and 20s for LEO600 and LEO1200 cases respectively.**
  + **One source observed that the positioning accuracy of less than 10km @90% UEs can be achieved with 24 seconds latency.**
  + **One source observed that the positioning accuracy of less than 10km can be achieved with 30, 60, 120 seconds latency with timing measurement errors of 100ns, 200ns and 300ns respectively where the timing measurement errors are assumed instead of simulated errors.**
  + **One source observed that the positioning accuracy of less than 10km @97% UEs can be achieved with 180 (LEO600) and 280 (LEO1200) seconds latency.**
* **One source observed that DL-TDOA cannot meet the target requirement for both earth fixed beam and earth moving beam.**

**For network verified UE location based on UL-TDOA positioning method** **with single satellite, assuming the ambiguity of the mirror image position is resolved:**

**Two companies commented on the suitability of the method:**

* **One source observed that UL-TDOA cannot meet the target requirement due to the open-loop TA update on UE**
  + **Note 1: This observation is not based on simulation results to prove that the requirement cannot met**
  + **Note 2: This observation is based on existing UL-TDOA method without additional NTN-specific enhancements**
* **Another source observed that UL-TDOA cannot meet the target requirement for both earth fixed beam and earth moving beam. With 60s latency positioning error performance that can be achieved is 43.46 km, CDF=90%.**

**Note-3: Error due to UE clock accuracy is not taken into account in the above observation. New simulations are needed by taking into account UE clock accuracy.**

**Note-4: 2D and 3D positioning methods should be distinguished in further discussion and conclusion**

**Note 5: RAN1 will revisit/update the above observation in RAN1#111 meeting by considering further evaluation results taking into additional NTN-specifics.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| Samsung | Fine with the observation. |
| LG | For Note-4, same comment in topic 1. |
| ZTE | OK with the proposal. In RAN1#110, RAN1 only agree to use 2D accuracy for performance evaluation. But 3D or 2D positioning is used is unclear. And 3D positioning methods should be considered by default since UE height is not guaranteed to be known by network. |

# Topic #3 Timing measurement error in NTN

## Background

Timing measurement error has a significant impact on positioning error performance. The following sub-sections aim at summarizing the different observations made in the contributions submitted to the RAN1#110bis with respect to timing measurement error in NTN.

## Companies’ contributions summary

A recap of timing measurement error in NTN assumptions considered in different contributions is provided within the following table:

|  |  |
| --- | --- |
| **Companies** | **Proposals** |
| ZTE | **Observation 2:** The timing measurement error of SRS and PRS can be smaller than 24ns and 6ns respectively with 95% probability under 30 degree elevation angle for LEO-600 set-1, rural LOS S-band scenario. |
| Oppo | The measurement error range could be assumed to be [-256Tc, 256Tc] as suggested by RAN4 for NTN TA estimation error.  Simulated DL-PRS based measurement error: 6ns  one PRS symbol instead of multiple PRS symbols joint detection, PRS bandwidth is 100 RB and the subcarrier spacing is 15kHz |
| CATT | **Observation 1:** The timing measurement error could not be ignored in both Multi-RTT and OTDOA positioning methods.  Assumption of Maximum timing measurement: <-6: 98Tc, -3>SNR>=-6: 42Tc, 0>SNR>=-3: 20Tc, 3>SNR>=0: 10Tc, SNR>=3: 1Tc.  **Proposal 4:** The SNR is the major factor to impact the PRS timing measurement error in AWGN channel, and the evaluated results of accuracy of PRS measuring in NR RAT-dependent position methods can be reused in NTN scenarios. |
| Xiaomi | **Proposal 2:** The RTT estimation error due to the movement of the satellite should be taken into account.  **Proposal 3:** The RTT estimation error on the feeder-link can be handled the gNB.  **Proposal 4:** The RTT estimation error on the service-link can be reported by the UE. |
| Qualcomm | max RTT timing measurement errors of 100 ns and 200 ns are considered. For 10 MHz BW, 100 ns is achievable with PRS and SRS |
| Huawei, HiSilicon | |  |  | | --- | --- | | **UE/gNB Tx/Rx calibration error** | Truncated Gaussian distribution with zero mean and standard deviation of T1 ns, with truncation of the distribution to the [-T2, T2] range, and with T2=2\*T1.  gNB Rx/Tx Time error T1 = 1.4ns  UE Rx/Tx Time error T1 = 5.6ns | |

## First round proposal 3

Based on the above, the following Initial proposed observation is made:

**Initial proposed observation 3:**

**Regarding Timing measurement error in NTN:**

**There is a consensus that the timing measurement error could not be ignored in time based positioning methods in NTN:**

* **One source observed that the timing measurement error of SRS and PRS can be smaller than 24ns and 6ns respectively with 95% probability under 30 degree elevation angle for LEO-600 set-1, rural LOS S-band scenario,**
* **One source observed that the measurement error range could be assumed to be [-256Tc, 256Tc] as suggested by RAN4 for NTN TA estimation error. And provided simulated DL-PRS based measurement error: 6ns,**
* **One source observed that the evaluated results of accuracy of PRS measuring in NR RAT-dependent position methods can be reused in NTN scenarios. Thereby, depending on the SNR maximum timing measurement error could be assumed to be: SNR <-6: 98Tc, -3>SNR>=-6: 42Tc, 0>SNR>=-3: 20Tc, 3>SNR>=0: 10Tc, SNR>=3: 1Tc,**
* **One source observed that max RTT timing measurement errors of 100 ns and 200 ns could be considered. For 10 MHz BW, 100 ns is achievable with PRS and SRS.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| Xiaomi | We are fine with the main bullet. |
| Samsung | We think that “There is a consensus that the timing measurement error could not be ignored in time based positioning methods in NTN:” is not needed.  Also, this is related to what measurement error values should be assumed for evaluation. Thus, we don’t think observation is not needed. Instead, we need to directly discuss which measurement error values are needed for evaluation purpose. |
| vivo | In our evaluation, we have tried even larger (up to 360ns) additional timing error, with proper measurement gap configured, the DL-TDoA method can still make sure of 5 to 10km positioning accuracy.  Therefore, we do not see the timing error would be an issue for DL-TDoA method.  Is the intention here to agree on a common timing error so that companies can simulate all timing-based methods in November meeting? |
| Nokia, Nokia Shanghai Bell | We agree that the timing measurement error of SRS and PRS cannot be ignored. Furthermore in order to be sure the methods fulfills the required accuracy, we propose to use the measurement error range of [-256Tc,256 Tc]  On top of this we would like to raise our concern related to the potential requirement (according to our understanding) that TDOA based solutions need to reset whenever the TA is updated/changed. |
| CATT | Support the alignment of timing measurement error model. |
| OPPO | Fine |
| NTT DOCOMO | Fine with the main bullet. We also agree with Samsung that the measurement error values can be discussed for calibration of evaluation. |
| Ericsson | We don’t think it is necessary to agree on this. The reported results are already captured in the FL summary. |
| SONY | It is unclear what the intention of the observation is (we seem to have a similar concern to Samsung and vivo): “Is the intention here to agree on a common timing error so that companies can simulate all timing-based methods in November meeting?” |
| Huawei, HiSilicon | Agree that we can discuss the aligned assumption for timing error. We also added our assumption in our simulation in the table. |
| ZTE | Fine with the proposal. But only main bullet is needed since consensus has been achieved. |

## Second round proposal 3

Based on the first round discussions, for further evaluations and the alignment of timing measurement error model proposed 3 is updated as follows:

**Updated proposed 3:**

**For the time based positioning methods in NTN, the timing measurement error range is assumed to be [-256Tc, 256Tc]**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| OPPO | For DL-PRS based DL-TDOA, our simulated mesaurement error is maximum [-6ns, 6ns]. Thus, we do not agreee with this proposal. |
| CATT | It is better to clarify SINR range, otherwise, not convinced to set exact error range. |
| Nokia, Nokia Shanghai Bell | OK |
| Samsung | We are generally fine with the proposal. However, the suggested values ±256 Tc are RAN4 requirements for NTN UE *Timing Advance* adjustment accuracy. We don’t know yet whether or not the timing measurements are performed using timing advance method. Other RTT timing measurement methods may have different measurement errors. |
| ZTE | We can agree that the timing measurement error cannot be ignored. But for the range, assuming a maximum range seems not suitable since the SNR impact will not be reflected. If this uniform range is assumed, there will be no performance difference between UL-TDOA and DL-TDOA. Simulated positioning error is more preferred. |
| vivo | Share similar view as OPPO, given the timing error would be different for positioning based on measurements on uplink and downlink, we propose have following updates:  **Updated proposed 3:**  **For the time based positioning methods in NTN, the timing measurement error range is assumed to be [-256Tc, 256Tc] for UL-TDOA and [-6ns, 6ns] for DL-TDoA.** |
| SONY | We think the timing measurement error should be differentiated between UL and DL.  What is the statistical distribution for the timing measurement error? Is the proposal to assume a uniformly distributed timing measurement error. |
| Huawei, HiSilicon | Based on the comments from companies, we do think we should align what is the timing error we discuss here.  In our simulation, we used the real estimation/measurement by correlation with local sequence to obtain the estimated timing. Therefore, in our simulation we do not need to model the timing estimation error based on some distribution in addition.  In our view, what should be considered is the UE/gNB Tx/Rx calibration error:   * Tx timing error: the time delay from the time when digital signal is generated at baseband to the time when the RF signal is transmitted from the Tx antenna; * Rx timing error: the time delay from the time when the RF signal arrives at Rx antenna to the time when the signal is digitalized and time-stamped at the base band.  |  |  | | --- | --- | | **UE/gNB Tx/Rx calibration error** | Truncated Gaussian distribution with zero mean and standard deviation of T1 ns, with truncation of the distribution to the [-T2, T2] range, and with T2=2\*T1.  gNB Rx/Tx Time error T1 = 1.4ns  UE Rx/Tx Time error T1 = 5.6ns | |

## Third round proposal 3

It was agreed in last RAN1 meeting that timing measurement error will be reported by companies. However, looking at the large variation in preliminary evaluation results it is necessary to align the assumptions on the timing measurement errors.

Based on the view expressed during second round. And the observations from different companies on the timing error. The Moderator recommends to agree on one of the options listed in 3rd round proposal:

**3rd round proposal 3:**

**There is a consensus that the timing measurement error could not be ignored in time based positioning methods in NTN. For further evaluation, one of the options below should be selection in current meeting:**

**Option 1:**

**The timing error to be considered is characterized with truncated Gaussian distribution with zero mean and standard deviation of T1 ns, with truncation of the distribution to the [-T2, T2] range: T2=2\*T1 with:**

* + **gNB Rx/Tx Time error T1 = 1.4ns**
  + **UE Rx/Tx Time error T1 = 5.6ns**

**Option 2:**

**For the time based positioning methods in NTN, the timing measurement error range is assumed to be [-256Tc, 256Tc] for UL-TDOA and [-6ns, 6ns] for DL-TDoA.**

**Option 3:**

**Depending on the SNR maximum timing measurement error could be assumed to be: SNR <-6: 98Tc, -3>SNR>=-6: 42Tc, 0>SNR>=-3: 20Tc, 3>SNR>=0: 10Tc, SNR>=3: 1Tc**

**Option 4:**

**Maximum** **timing measurement errors of 100 ns and 200 ns could be considered.**

* + **For 10 MHz BW, 100 ns is achievable with PRS and SRS.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| Samsung | We would rather select a simple, yet worst case option. That is, we select Option 4. |
| ZTE | In option 1, only the Rx/Tx error are assumed. The measurement error is not clear. Does that mean the measurement error depends on the simulation result, and total error is sum of Rx/Tx error and measurement error? If so, we can support option 1. If the error in option 1 is regarded as overall error, we do not support.  If a simpler assumption which covers all factors is to be used, option 3 is more preferred than option 2/4 since option 3 considers the impact of SNR. |

# Topic#4 Latency of UE location verification

## Background

The following was recommended in TR 38.882: The solution should not impact significantly the latency of the targeted services nor infringe privacy requirements that apply to the UE location. Further, the required latency for different regulated services are captured in the appendixes in TR 38.882 and recopied hereafter:

|  |
| --- |
| A.1 Emergency calls  Latency  The delay to determine the UE location should be minimised to ensure timely assistance or rescue,  While a typical call set-up is less than a second, the delay for UE location determination should not impact significantly this communication set-up time.  A.2 Lawful intercept (LI):  Latency  No regulatory requirement have been identified for this. Despite this, NTN location determination should not significantly impact the LI service as provided by an TN network.  A.2 Lawful intercept (LI):  Latency  No regulatory requirement have been identified for this. Despite this, NTN location determination should not significantly impact the LI service as provided by an TN network.  A.3 Public warning Service (PWS):  Latency  No regulatory requirement have been identified for this. Despite this, NTN location determination should not impact significantly the PWS service as provided by an TN network.  A.4 Charging and Tariff notifications:  Latency  No regulatory requirement have been identified for this. Despite this, NTN location determination should not significantly impact the charging/tariff service as provided by an TN network. |

## Companies’ contributions summary

The following was proposed in the Tdocs submitted to RAN1#110-bis w.r.t the latency of UE location verification:

|  |  |
| --- | --- |
| **Companies** | **Proposals** |
| Thales | 1. The time period required to calculate uplink multi-RTT measurement is excessively long in case of multi-RTT based positioning method is used with single satellite in view which makes the feasibility of the method questionable.   Proposal 2: RAN1 to send LS to RAN2/SA1 requesting inputs on the acceptable maximum latency to carry out the UE location verification procedure |
| Xiaomi | Observation:   * The measurement interval, and the satellite orbit have significant impact on the positioning accuracy * The delay for verifying the location is at least 10s and 20s for LEO600 and LEO1200 cases respectively.   **Proposal 6:** The delay required for verifying the location needs to be further considered to avoid the impact to the service. |
| Ericsson | Observation 1 Only the UE reporting an incorrect UE location will experience a potential delay in service.  Proposal 2 Send LS to RAN plenary to seek a clarification on the interpretation of latency requirements and trust in UE RRC measurements (and if it is actually the RRM measurements that is meant instead of the RRC measurements). What measurements can be trusted? When and how often does the network need to verify the UE reported location? In case UEs shall be denied service until the UE reported location is verified by the network, what is an acceptable delay for the network verification procedure? |
| PANASONIC | **Observation 2:** A measurement window in the order of seconds may be required to achieve the required accuracy.  **Observation 4**: The interval between RTT-measurements has a stronger impact on the accuracy of UE location estimation than the number of RTT-measurements. |

## First round proposal 4

As discussed within section 1 and 2, and as raised by some companies, the latency of UE location verification needs to be further considered to avoid the impact to the service.

Based on the above, the following initial proposal is made:

**Initial Proposal 4:**

RAN1 to send LS to SA1 (Cc RAN2) requesting inputs on the acceptable maximum latency to carry out the UE location verification procedure.

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| Apple | Fine with the proposal. |
| Samsung | We are open to discuss on sending LS. If possible, it might be better to include potential (agreed) RAN1 observations about performance results in order to provide that other working group understand for the range that the current specification can support. |
| Panasonic | OK for us. |
| vivo | Latency is not a problem as positioning does not have to be performed so frequently for verifying UE location。  The maximum latency could be determined by the time that a UE can be served by one single satellite, which could be up to around 10 minutes and less than 20 minutes for LEO satellite on a 2-hour orbit depending on the number of beams it has according to 38.811. These values are enough to perform the location verification based on the measurement gaps we used in the evaluation. |
| Nokia, Nokia Shanghai Bell | OK |
| CATT | Support |
| LG | Fine with the proposal. |
| Lenovo | We refer to end-to-end latency that comprises of physical layer latency (e.g., measurement and processing) and CN latency by the higher layer (as studied in Rel-17 e-Pos SI). Physical layer latency may be defined/calculated by RAN 1 while LS can be sent to RAN2/SA2 to define/calculate the CN latencies for performing the NTN verification procedure. |
| Intel | It is good to check whether there are additional requirements on latency.  RAN shall be in the Cc list as well. |
| OPPO | Ok in principle, however it would be needed to define the latency, e.g. when is the T0 time. |
| MediaTek | ok |
| NTT DOCOMO | Fine with the proposal. |
| Ericsson | We support the proposal. We should also ask for clarification on if location has to be verified before the UE is provided service. |
| SONY | OK |
| Huawei, HiSilicon | The verification procedure should not be performed frequently for a UE. Therefore, the latency of verification should not impact the service latency too much. Maybe RAN1 could give a view that on how many seconds RAN1 could support by the solution, and ask SA whether it is OK for the verification.  We should also align how to define the latency here, e.g. the time used by PHY to obtain needed measurement, and whether it includes the time for the reporting of measurements. |
| ZTE | Basically fine with the proposal. Moreover, it seems better to also provide the latency value identified by RAN1 for location verification to SA1 to check whether it is affordable, instead of only requesting the acceptable maximum latency. What will RAN1 do if SA1 only reply a value shorter than current latency? Should we optimize location verification method to satisfy the SA1 requirement or consider other solution? |

## Second round proposal 4

Initial Proposal 4 was discussed at the GTW on October 12th. But there was no consensus on sending the LE to SA1.

Based on 1st round feedback: the majority support the proposal. Companies [**Apple, Samsung, Panasonic, Nokia, Nokia Shanghai Bell, CATT , LG, Lenovo, Intel, OPPO, MediaTek, NTT DOCOMO, Ericsson, SONY, Huawei, HiSilicon, ZTE**] are fine with sending the LS to SA1 about the latency.

According to [**vivo**] Latency is not a problem as positioning does not have to be performed so frequently for verifying UE location. From Moderator’s point of view, the latency might be an issue. We do not know yet whether the verification should be done before the UE is provided service (PDU session establishment) or in parallel to the call (PDU session)/when the UE is being provided the service. If before, the service it is clear that the latency is major issue.

Further, it is not true that the UE location verification does not have to be so frequent. At last there is no agreement or working assumption on that. We really need inputs from SA1. As mentioned in section 1.5 at least by considering the fact that SA3-LI has established the requirement that "any solution shall support the ability to enforce the use of a Core Network of PLMN in the country where the UE is physically located” it might be necessary to trigger the verification procedure frequently, at least at the registration/UE attach, at registration updated, service request, PDU session establishment.

Some companies want to include further aspects as discussed in next section: potential (agreed) RAN1 observations about performance results/ RAN1 could give a view that on how many seconds RAN1 could support by the solution. Other companies want align on latency definition.

Moderator’s view: All these comments are valid and need to be taken into account in the text of the LS. The moderator will share via RAN1 reflector a text proposal but the group need first to agree the need of sending the LS.

This Proposal will be discussed directly via RAN1 reflector for a potential agreement at the check point of October 14th:

**Updated Proposal 4:**

RAN1 to send LS to SA1 (Cc RAN2) requesting inputs on the acceptable maximum end to end latency to carry out the UE location verification procedure.

## Third round proposal 4

This Proposal is being discussed directly via RAN1 reflector

# Topic#5 Network verified UE location based on UE TA reporting

## Background

In the TR 38.882 it was observed that at least some of the information the UE supplies to the network will have to be considered as trusted, to avoid extreme conclusions (at least RRC measurements cannot be faked).

Also, it was recommended in TR 38.882 that the verification should be performed independently from the location information reported by UE.

## Companies’ contributions summary

The following views were expressed with respect to TA report based verification method:

|  |  |
| --- | --- |
| **Companies** | **Proposals** |
| MediaTek | **Proposal 2**: RAN1 study finer than 1 ms granularity for UE-specific TA report via MAC CE.  **Proposal 3**: RAN1 study configuration of time interval between each UE-specific TA report to allow sufficient accuracy of the verification of the UE position in single satellite scenario. |
| ZTE | **Observation 7:** TA report supported in Rel-17 NTN can be used for RTT estimation.  **Observation 8:** TA report accuracy is not affected by SNR.  **Observation 9:** TA reported by UE can be considered to have similar reliability as other RAT dependent parameters since it is related to UL synchronization.  **Proposal 4:** TA report based location verification method can be investigated as alternative to legacy multi-RTT positioning method.  **Proposal 5:** TA report with higher granularity can be investigated to improve the location verification performance. |
| OPPO | **Observation 1:** whether a TA reported by a non-trustful UE is considered to be trustful is a key question for multi-RTT method based on UE reported TA.  **Proposal 1:** RAN1 to send an LS to SA3 to ask for the confirmation on whether a TA reported by a non-trustful UE is considered to be trustful for positioning purpose. |
| Sony | **Observation 1:** A malicious UE intent on reporting a fake location can also report fake location verification measurements commensurate with its fake location.  **Proposal 3:** RAN1 shall define network location verification methods that are immune to spoofing by malicious UEs intent on reporting a fake location. |
| Apple | **Proposal 8:** In NGSO scenario with multi-RTT positioning method, do not support the scheme that RTT is obtained as the sum of UE reported total TA and the timing error of the uplink reference signal |
| Ericsson | **Proposal 1** UE reporting of timing advance cannot be trusted for the purpose of network-verified UE location in NTN.  **Observation 2** Existing RRM measurements for intra-RAT neighbours, inter-RAT neighbours, etc. can be trusted for location verification with the required location accuracy. They may, however, not be available on all locations on earth.  **Proposal 2** Send LS to RAN plenary to seek a clarification on the interpretation of latency requirements and trust in UE RRC measurements (and if it is actually the RRM measurements that is meant instead of the RRC measurements). What measurements can be trusted? When and how often does the network need to verify the UE reported location? In case UEs shall be denied service until the UE reported location is verified by the network, what is an acceptable delay for the network verification procedure? |
| Qualcomm | **Proposal 1**: Support TA report of an SRS transmission for network verification of UE location. |
| LG Electronics | **Proposal #2:** For RTT determination, option 1 is supported.  - Option 1: The multi-RTT positioning method makes use of the UE Rx-Tx time difference measurements of downlink signals (i.e. PRS) received from the satellite, measured by the UE and reported to the gNB and the measured gNB Rx-Tx time difference measurements, of uplink signals transmitted from UE (i.e. UL-SRS). |

The summary of views expressed by companies in their contribution is as follows:

**[MediaTek, ZTE, Qualcomm]** Support TA report for network verification of UE location and proposed to further study TA reporting with finer granularity which can be used for RTT estimation (ZTE, Qualcomm) or for the verification of UE location based on multiple RTT with prediction as proposed by MediaTek in [5].

**[OPPO]** observed that whether reported TA is considered to be trustful is a key question for multi-RTT method based on UE reported TA.

**[Sony]** observed that a malicious UE intent on reporting a fake location can also report fake location verification measurements commensurate with its fake location.

**[Apple, Ericsson]** observed thatUE reporting of timing advance cannot be trusted.

Companies **[OPPO**, **Ericsson**] proposed for RAN1 to send an LS to SA3.

From Moderator’s perspective and based on the TR 38.882 recommendations, it is clear that the UE location verification should be performed independently from the location information reported by UE. But, it is not yet clear whether it can be performed based on information which is derived/calculated by the UE based on its GNSS e.g. UE specific TA. As stated in the TR 38.882, the UE reported location information (for example determined with its GNSS receiver), could be erroneous due to intentional (e.g. maliciously tampering by user or by 3rd party) or unintentional (e.g. interference) causes, hence it cannot be considered trusted see S3i200056.

In Moderator view, information reported by the UE such as UE specific TA which is in essence computed by the UE using its GNSS-acquired position and the serving satellite ephemeris might be also untrusted. Therefore, more discussion is needed. And possibly an LS to SA3 in this regards might be necessary.

## First round proposal 5

Based on the discussion is previous section, the following Initial Proposal is made:

Initial Proposal 5:

RAN1 to send LS to SA3 asking whether the UE location verification could be performed based on information the UE supplies to the network which is derived by the UE based on its GNSS (e.g. UE Specific TA, Doppler shift, Radial satellite velocity etc..).

**Note: SA3#108-Ad Hoc-e – Meeting is scheduled from 10th to 14th of October. Hence, the LS should be sent as soon as possible during the RAN1 meeting.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| QC | OK |
| Apple | We do not think the LS to SA3 is necessary. If UE reported location information based on GNSS measurement is not considered as trusted, it does not make sense that the TA reporting which is also based on GNSS measurement is considered as trusted.  It is clearly recommended in TR38.882 that “The verification should be performed independently from the location information reported by UE”. The TA reporting is NOT independent of the location reporting from the UE, since both are derived from GNSS.  Furthermore, the TA reporting is an optional UE feature. In other words, not every UE supports this feature. It is improper to explore UE’ TA reporting feature for UE location verification purpose.  Overall, this kind of discussions should be deprioritized. |
| Xiaomi | Fine |
| Samsung | We tend to agree with moderator’s view and it needs more investigation on the feasibility of using UE specific TA value. |
| Panasonic | Not supportive. It has been established that RAN1 shall consider GNSS data provided by the UE as not trustworthy. The aim is clearly to rely as little as possible on the UE when verifiying its location. It seems to us that if reported GNSS-location data is deemed unreliable, then any other reported data derived from GNSS is deemed unreliable as well. |
| vivo | If the location verification is based on the pre-compensation derived from the satellite position based on the ephemeris information and UE position estimated by GNSS, why not use GNSS positioning results directly?  We do not think the enhancement of the TA report is necessary and propose to prioritize DL-TDoA method not requiring such enhancement according to the evaluations performed and the results observed. |
| Nokia, Nokia Shanghai Bell | OK, but there may be an inherent conflict related to the UE privacy. |
| CATT | Not supportive.  If GNSS measurement is trustable, then no need to discuss the RAT-dependent solution. This will lead to go back to original point. |
| LG | We share the view with Apple. |
| Lenovo | Support the proposal. |
| Intel | In our view RAN1 shall focus on network-based positioning methods not relying solely on GNSS-related report. So, in our view LS is not needed. |
| OPPO | Agree, and the draft LS needs to be discussed. |
| MediaTek | Mainly fine with moderator proposal, the text of the LS should include further aspects as discussed in next section |
| NTT DOCOMO | Fine |
| Ericsson | We support the proposal. |
| SONY | The TA is derived from the UE’s GNSS measurement. Hence the TA is dependent on the location information reported by the UE. Use of the TA to verify UE location hence doesn’t satisfy the recommendation in TR38.882 that, “The verification should be performed independently from the location information reported by UE”.  Maybe RAN1 could agree on the following observation:  **Proposed observation:**  **“Use of the TA report from the UE for the purposes of location verification does not allow for verification to be performed independently from the location information reported by UE.”** |
| Huawei, HiSilicon | Fine to have an LS to clarify. |
| ZTE | Basically fine. But in our view, the reported TA is not solely based on reported GNSS information. The TA will be used for UL synchronization and scheduling, which are RAT procedures. If wrong TA is applied, the UL sync may be lost. Hence, TA should be a reliable parameter, which is different from the reported UE location. |

## Second round proposal 5

The views provided at first round and during the GTW session on LS to SA3 can be summarized as follow:

13 companies support or fine with sending the LS to SA3: [**Qualcomm, Xiaomi, Samsung, Nokia, Nokia Shanghai Bell, Lenovo, OPPO, MediaTek, NTT DOCOMO, Ericsson, Huawei, HiSilicon, Thales, ZTE**]

6 companies do not support sending the LS to SA3: [**Apple, Panasonic, CATT, LG, Intel, SONY** ], the reason provided by these companies is the same: if reported GNSS-location data is deemed unreliable, then any other reported data derived from GNSS is deemed unreliable as well.

Moderator’s views: The majority is supportive of sending the LS to SA3. For other companies (not supportive) the LS is not needed because it is evident that any reported data derived from GNSS is deemed untrustworthy. Based on this, the way forward could be: To adopt the following working assumption. Because any solutions based on TA reporting would not be acceptable to all companies. And sending the LS to SA3 to confirm/or not the working assumption based on SA3 reply.

The following WA is proposed, companies are also encouraged to comment on the updated proposal 5 below:

**Working assumption:**

**TA reporting and any information the UE supplies to the network, which is derived by the UE based on its GNSS is considered as untrusted and thereby does not allow for UE verification to be performed independently from the location information reported by UE.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| OPPO | agree |
| CATT | Support |
| Lenovo | Support |
| Intel | We prefer to relax this assumption a little bit since the TA report may still be used in combination with other information (e.g. based on SRS measurements for UL-TDOA). In some cases reported TA cannot be faked in a way that prevent detection of wrong UE position, so the goal of verification can still be achieved. Thus, we propose the following wording change.  **TA reporting and any information the UE supplies to the network, which is derived by the UE based on its GNSS is considered as untrusted and thereby does not allow for UE verification to be performed independently from the location information reported by UE if verification is solely based on the information derived by the UE based on its GNSS.** |
| Apple | Support.  Alternatively, we are fine to make the above working assumption as a conclusion.  Overall, we think the discussion on network versifying UE location approach based on TA reporting should be deprioritized. Logically, it does not make sense that UE’s reported GNSS location is untrusted while the reported TA information which is derived from UE’s GNSS location is trusted. |
| Nokia, Nokia Shanghai Bell | Support original version of the working assumption |
| Samsung | According to 38.882 “The UE reported location information (for example determined with its GNSS receiver), could be erroneous due to intentional or unintentional causes.”  38.882 also says “At least some of the information the UE supplies to the network will have to be considered as trusted.”  This does not necessarily mean that the reported TA is intentionally erroneous.  However, we are fine if we want to make such a deduction/conclusion and assume that any information derived from the UE based on its GNSS won’t be trusted. |
| MediaTek | Not support. We are not clear on the intention of this proposal.  The UE has to have a valid GNSS to transmit to UL. A malicious UE will have to fake a UE\_specific TA report. If UE can do this, it is reasonable to assume that any measurement report from the UE can be faked. Any information reported by the network (GNSS report, TA report, RSRP measurement report, RSTD report, RTT measurement report) can be faked. It would be strange if RAN1 make assumption that UE can fake UE-specific TA report because it is derived from GNSS (though UE must have a valid GNSS to report the UE-specific TA), but the UE cannot fake RSRP measurement report, or RSTD measurement report, or RTT measurement report. |
| LG | Support |
| ZTE | Not support. The reported TA is not solely for location verification. The TA is originally introduced to achieve UL synchronization. At least the TA applied in UL synchronization in physical layer is a correct one. Otherwise, UL sync will be lost and scheduling issue will happen. Therefore, the “malicious intent” should not include the physical layer parameter report including the TA report. If UE can report a fake TA that is different from the correct TA applied in physical layer, it means UE can also report fake information for other physical parameters or measurements, including RSTD measurement report in DL-TDOA or Rx-Tx time difference report in multi-RTT. Then any positioning method that requires UE report cannot be trustable. |
| vivo | We share similar view as many companies that the LS is too early at this stage for the following reasons:   * Latency definition being talked about here are not clear. * RAN1 should focus on which latency is needed for each method (agreed to be prioritized in last RAN1 meeting) to achieve 5-10km accuracy based on the evaluations.   The simulation results we have in this meeting for the prioritized methods agreed in last meeting show that some methods can already achieve 5-10km accuracy with some measurement time assumed, however the time required are different as different simulation assumptions are used and it’s hard to conclude which measurement time/latency is needed for each method to achieve 5-10km accuracy. This means more evaluations with common simulation parameters are needed in RAN1 to further check the methods so that positioning latency values needed for each method from RAN1 point of view can be provided to RAN2 and/or SA to further decide whether they are acceptable. For the other latency values that RAN1 people are not familiar with can be up to SA/RAN2 to discuss. They can make a decision on whether RAN level positioning is needed taking into account input from RAN1 and other aspects not in the area of RAN1. |
| SONY | Support.  We think that TA reporting cannot be used in conjunction with other verification information if the TA report is based on the GNSS location. Isn’t it the case that sending both a TA report and an UL-TDOA measurement is equivalent to sending a GNSS location and an UL-TDOA measurement? In that case, what is the point of sending the TA report at all? We would be sending a GNSS location and an UL-TDOA measurement to verify a GNSS location!?! |
| Huawei, HiSilicon | Support. |

**Updated Proposal 5:**

RAN1 to send LS to SA3 asking whether the UE location verification could be performed based on information the UE supplies to the network which is derived by the UE based on its GNSS (e.g. UE Specific TA, Doppler shift, Radial satellite velocity etc..).

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| OPPO | Reporting TA is not a method independent of GNSS. This should be clear and this is not in line with RAN plenary guidance. Thus with this, we tend to agree with other companies that LS may not be needed. |
| Panasonic | Same view as OPPO |
| Lenovo | We are fine with sending the LS. We also think that TA reporting is based on GNSS and may not be trusted for position verification procedure. In our point of view, SA3 can clarify this issue. |
| Apple | This LS depends on the relevant RAN1 agreement/assumption. At this moment, we do not see the need of this LS. |
| Ericsson | We support the LS as this will remove any ambiguity about trustworthiness and help RAN1 identify the correct solution. |
| Nokia, Nokia Shanghai Bell | We already posted our view directly on the mail reflector. For completeness it is repeated here:  Here I am a bit in doubt whether this fits with the working assumption. If we in RAN1 assume that GNSS based information is not trustworthy, which kind of input would we like to have from SA3 in this connection?  Basically the proposed working assumption states that “UE information that is based on or derived from GNSS information cannot be trusted”. Since the GNSS information may invalid due to various reasons (UE internal or external tampering), I am not sure if SA3 would be able to assist in this matter (how would SA3 be able to ensure that external tampering is not happening?).  At least we should be very specific with respect to the question to SA3 such that they know which kind of information we are asking for clarification for. |
| Samsung | If we agree upon the working assumption above then we should send an LS to SA3 and share our deduction reasoning about the UE’s information based on its GNSS to see if SA3 share the same view. So we suggest rewording the Proposal as the following:  RAN1 to send LS to SA3 to share RAN1’s views on whether or not the UE location verification could be performed based on the information that the UE supplies to the network which is derived by the UE based on its GNSS (e.g. UE Specific TA, Doppler shift, Radial satellite velocity etc..) and seek SA3’s opinion whether they share the same view. |
| ZTE | We are OK to send LS to SA3 if majority agree. However, there is no consensus on the deduction reason on the TA reliability. As commented above, TA is used for synchronization procedure instead of only for location verification. UE applying an incorrect TA cannot access the network. Hence, TA report reliability is similar to report of other physical layer parameters, e.g., RSTD measurement report in DL-TDOA or Rx-Tx time difference report in multi-RTT. The LS should be sent to check whether TA report based method can be acceptable with above information instead of simply saying TA is derived based on GNSS and ask reliability. |
| vivo | Agree that RAN1 can just take this working assumption and focus on those methods not requiring TA report first. If those methods can work with proper latency, no further discussion on TA report is needed. |
| SONY | We think that the working assumption is enough and we don’t need to send an LS to SA3. |
| Huawei, HiSilicon | If we can agree the working assumption, we are open to send LS. If we don’t have any assumption in RAN1, we don’t like to send LS considering it would just block the discussion in RAN1. |

## Third round proposal 5

This Proposal is being discussed directly via RAN1 reflector

# Topic#6 TP for LS on network verified UE location based on UE TA reporting

## Background

Refer to section 5.1

## Companies’ contributions summary

Refer to section 5.2

## First round proposal 6

Based on the Initial Proposal 5 (if agreed), a draft LS hereafter is proposed as follows:

**Initial proposal 6**

**Companies are encouraged to comment on the following draft LS** **about network verified UE location based on UE TA reporting:**

|  |
| --- |
| 3GPP TSG RAN WG1 #110bis-e R1-22xxxxx  e-Meeting, October 10th – 19th, 2022  **Title:**[Draft] LS on network verified UE location based on UE TA reporting  **Release:**                  Rel-18  **Work Items:**          NR\_NTN\_enh  **Source:**                   Thales ( to be RAN WG1)  **To:**                           SA3  **CC:** -  **Contact Person:**  **Name:**                 Mohamed EL JAAFARI  **E-mail Address:** [mohamed.el-jaafari@thalesaleniaspace.com](mailto:mohamed.el-jaafari@thalesaleniaspace.com)  **Send any reply LS to: 3GPP Liaisons Coordinator:** [**mailto:3GPPLiaison@etsi.org**](mailto:3GPPLiaison@etsi.org)  **Attachments:**          -  **1. Overall Description:**  As part of Release 18, a new work item is proposed to define enhancements for NG-RAN based Non-Terrestrial Networks in order to address requirements which mandate the network to cross check the UE location reported by the UE, which needs to be carried out in order to fulfil the regulatory requirements (e.g., Lawful intercept, emergency call, Public Warning System, …).  At RAN1#110, RAN1 started the study and the evaluation of potential solutions for the network to verify UE reported location information.  Relying only on the GNSS based location information reported by the UE is not considered reliable by SA3-LI [3GPP S3i200056].  Further, as stated in the TR 38.882, the UE reported location information  (for example determined with its GNSS receiver), could be erroneous due to intentional (e.g. maliciously tampering by user or by 3rd party) or unintentional (e.g. interference) causes, hence it cannot be considered trusted by network operators.  Also, as observed in the TR 38.882, at least some of the information the UE supplies to the network will have to be considered as trusted, to avoid extreme conclusions (at least RRC measurements cannot be faked). However,  some of the information reported by the UE may be derived by the UE based on its GNSS (e.g. UE Specific Timing Advance (TA) which calculated by the UE using its GNSS-acquired position and the serving satellite ephemeris)  RAN1 identified the following question that need clarification from RAN4:  **Question**: Whether the UE location verification could be performed based on information the UE supplies to the network which is derived by the UE based on its GNSS (e.g. UE Specific TA, Doppler shift, Radial satellite velocity etc..)?  **2. Actions**  **To SA3**  **ACTION**:         RAN1 respectfully asks SA3 to provide feedback on the above question  **3. Date of Next TSG-RAN WG1 Meetings:**  TSG-RAN1 Meeting #111,Toulouse      14 Nov - 18 Nov 2022 |

Companies are encouraged to provide views/edits within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| Apple | As we commented in Proposal 5, the LS is not needed at all. |
| Samsung | We are fine with the LS. But, the following should be changed to SA3.  RAN1 identified the following question that need clarification from RAN4. |
| Panasonic | We are not supportive of this LS. See our reply to Initial proposal 5. |
| vivo | The LS is not needed before we conclude which method is enough for UE location verification. |
| Nokia, Nokia Shanghai Bell | In principle OK, but we should not be limiting to information provided by the UE (UE performs measurements and feed information to network), but could also consider solutions where the gNB obtains information based on UE transmissions. |
| CATT | Not needed. |
| LG | The LS is not needed. |
| Lenovo | Support the LS. |
| Intel | LS is not needed |
| OPPO | We suggest the following rewording to make the question clear.  **Question**: Whether the UE location verification ~~could be performed~~ based on information the UE suppl~~ies~~ying to the network, which is derived by the UE based on its GNSS (e.g. UE Specific TA, Doppler shift, Radial satellite velocity etc..), is considered reliable by SA3? |
| MediaTek | The LS could include other report types from UE. To our understanding, anything reported by the UE can be faked – i.e. UE-specific TA report, RSRP report, RSTD measurement report for DL-OTDOA, RTT measurement report for multiple RTT. It is a bit strange to indicate concern for UE-specific TA report because it is derived from GNSS that can be faked, but imply other types of reports cannot be faked.  On GNSS interference, the UE needs to have a valide GNSS for UE pre-compensation for UL synchroniatio or it cannot transmit on UL to send report. |
| Ericsson | We support this LS. Also, we share the same views as MediaTek and the LS can be revised to include that. |
| SONY | Not needed. See our reply to initial proposal 5. |
| ZTE | In our view, the reported TA is not solely based on reported GNSS information. The TA will be used for UL synchronization and scheduling, which are RAT procedures. If wrong TA is applied, the UL sync may be lost. Hence, TA’s reliability should be similar as other RAT-dependent reported parameters, e.g., DL-TDOA measurements. With above consideration, we agree with MediaTek that other reported information should be included in the LS for SA3 comment. And it is preferred to clarify that TA is related to synchronization and scheduling, whose reliability is more similar to RAT related parameters instead of reported UE location which has no impact on cellular operation. |

## Second round proposal 6

The TP for the LS will be further discussed when updated proposal 5 is agreed

## Third round proposal 6

The TP for the LS will be further discussed when updated proposal 5 is agreed

# Topic#7 Evaluation of UL-AoA based positioning techniques in NTN

## Background

It was agreed in last RAN1 meeting to evaluate Multi RTT and DL/UL-TDOA as starting point and it was noted that other methods such as AoA based techniques are not precluded.

## Companies’ contributions summary

The following views were expressed with respect to UL-AoA based positioning techniques in NTN for Network verified UE location in NTN :

|  |  |
| --- | --- |
| **Companies** | **Proposals** |
| Thales | Observation 6. Different techniques for angle-based positioning can be used to estimate UE location depending on satellite antenna architecture and whether digital, analog or hybrid beamforming are used.  Observation 7. The result of the UL-AoA based positioning is a point on Earth, with a certain angular accuracy. Different defects may affect the angle estimation such as satellite beam pointing error, phase noise and defects due to all transformations (or operations) applied on the signals, from AE on board to the receiving base station on the ground.  Observation 8. The main advantage of UL-AoA positioning method is the low latency and its applicability for the GEO based NTN deployment  Observation 9: The characteristics of the SRS signal transmitted by the UE should be static over the time period required to calculate uplink AoA measurements. NTN environment impact (e.g. timing drift) on SRS should be further studied.  Proposal 4: RAN1 should study angle-based positioning techniques in NR NTN  Proposal 5: RAN1 to discuss the achievable location accuracy with the uplink angle of arrival techniques in NGSO and GSO based NTN deployment  Proposal 6: RAN1 should evaluate SRS coverage for UL-AoA and study NTN environment impact (e.g. timing drift) on SRS. For evaluation purposes, NR NTN SRS for Positioning reuses the Rel-16 NR sequence design and resource mapping as baseline.  Proposal 7: To enhance UL-AoA based positioning performance in NTN, consider auto-calibration process to compensate for satellite beam pointing error, this includes:   * Use of beacon uplink signals to adjust satellite beam pointing, * Zadoff-Chu sequence used for the SRS maybe beacon specifically configured as a potential solution to introduce such beacon signals in NR NTN with a minimum specification impact. |
| Lenovo | **Proposal 8:** RAN1 to further study DL/UL angle-based and NR ECID positioning techniques and associated adaptations for NTN to verify the UE reported location. |
| Ericsson | **Observation 4** It may be feasible to use the angle of arrival method in combination with other methods for network verified UE location depending on the achievable angle resolution at the satellite.  **Proposal 3** RAN1 to discuss the achievable accuracy with the angle of arrival method, and with the E-CID method based on measurements on the same satellite as well as hybrid combinations. |
|  |  |
|  |  |

## First round proposal 7

Based on the views expressed within the contributions submitted to RAN1#110bis with respect to UL-AoA based positioning techniques, the following proposal is made:

**Initial Proposal 7:**

**RAN1 to further study DL/UL angle-based positioning techniques in NR NTN:**

* **Discuss the achievable location accuracy with the uplink angle of arrival techniques in NGSO and GSO based NTN deployment**
* **Evaluate SRS coverage for UL-AoA and study NTN environment impact (e.g. timing drift) on SRS**
* **Discuss whether enhancements are necessary to meet Network verified UE location requirements**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| QC | The AOA accuracy is limited by satellite antenna. To achieve reasonable positioning accuracy, the required AoA as shown by some companies is orders of magnitude less than the beam angular BW. We don’t see the feasibility and don’t think we should spend more time on it. |
| Apple | We prefer to focus on timing-based positioning techniques. The angle-based positioning techniques can be deprioritized.  It is unclear why uplink AoA techniques works for GSO based NTN deployment, considering the single satellite case. |
| Panasonic | OK for us |
| vivo | This proposal is not necessary as timing based method is already enough according the evaluations performed.  So, angle based methods can be deprioritized. |
| Nokia, Nokia Shanghai Bell | As stated in our response to P1 and P2, we believe angle (AoA/AoD) based techniques can be one of the possibilities to solve the mirror points ambiguity from the timing based methods and from a specifications point of view using the uplink angle technique looks most attractive. |
| CATT | Since the technical reason is not holding, the angle-based positioning techniques can be deprioritized. |
| LG | As commented by QC, feasibility of angle based positioning should be checked firstly. |
| Intel | We are fine with the proposal |
| MediaTek | Mainly fine with proposal. Since UE needs to pre-compensate delay before transmitting SRS, the UE-specific report needs to be transmitted for the SRS for gNB to estimate the RTT and angle of arrival. |
| NTT DOCOMO | Is it possible to achieve AoA measurement by NTN deployment with transparent payload? Considering large propagation delay in NTN scenario, the accuracy of AoA methods may not be promising as well. We also prefer to focus on timing-based positioning techniques. |
| Ericsson | The first sentence mention “DL/UL angle-based…” but the sub-bullets only refer to “UL” AoA – perhaps “DL” can be removed.  We agree that UL AoA will require high angular resolution but it may be combined with other techniques. We are ok with the proposal on further studying these methods. |
| SONY | We are concerned about the accuracy of AoA-based techniques. However, at this stage of the WI, it is OK to further study along the lines in the proposal. |
| ZTE | The feasibility of UL-AoA method is questionable since the satellite antenna may not able to well estimate the angle. For DL-AoA method, FR1 UE generally cannot estimate the angle in reality. Hence, the timing based method can be considered with high priority than angle based method. |

## Second round proposal 7

Based on the first round discussions:

7companies [ **Qualcomm, CATT, LG**] don’t see the feasibility and/or want to focus on timing-based positioning techniques [Apple, vivo, NTT DOCOMO, ZTE]

7 Companies supportive or fine to further study [**Panasonic, Nokia, Nokia Shanghai Bell, Thales, Intel, MediaTek, Ericsson, SONY**]

Moreover, companies [**Nokia, Nokia Shanghai Bell, Thales, Ericsson**] share the view that AoA method may be combined with other techniques.

Moderato’s view: It is true that AoA based method might be affected by several defects which may have a significant impact on the achievable accuracy and its cost may also be an issue. But it is premature to conclude on the feasibility of the method at this stage. Also, Moderator shares the same view as Ericsson and Nokia on combining this method with others methods (for example to solve the ambiguity of the mirror image position). As we have only one remaining meeting (November meeting) to conclude the study, Moderator highly encourage companies to consider AoA for the evaluation. At this stage it is absolutely not sure that time based method alone would be the solution for network verified UE location.

Companies are encouraged to read each other view on this topic. The following proposal is for further discussion during the second round:

**Second round Proposal 7:**

**RAN1 to further study DL/UL angle-based positioning techniques in NR NTN:**

* **Discuss the achievable location accuracy with the uplink angle of arrival techniques in NGSO and GSO based NTN deployment**
* **Evaluate SRS coverage for UL-AoA and study NTN environment impact (e.g. timing drift) on SRS**
* **Discuss whether enhancements are necessary to meet Network verified UE location requirements**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| OPPO | Fine to further study, but we suggest to make higher priority on the timing based positioning methods. |
| CATT | Deprioritize the angle based position method |
| Panasonic | We agree with FL’s proposal. |
| Lenovo | Support the proposal and agree with moderato’s view |
| Apple | A clarification question: If we assume it is single satellite case, then how to achieve location accuracy with the uplink angle of arrival in GSO?  Based on RAN1 #110 meeting agreement, the starting point for network verified UE location is multi-RTT and DL/UL-TDOA. Hence, we think UL-AoA could be put in relatively low priority. |
| Ericsson | Support |
| Nokia, Nokia Shanghai Bell | We support the general scope of the updated proposal 7, but would prefer to allow for more options to be available for performing the UL AoA investigations. After all, we would prefer that the primary validation approach is decoupled as much as possible from the potential tampering of the GNSS (both for the reporting and for the UE applying modifications to the signal). For instance, one could consider the UE to be transmitting signals that are not modified by the UE at all. That is, no UE autonomous frequency offset compensation and no UE autonomous timing advance. In this way, the received signal would be representative of the UE’s actual position relative to the satellite and allow for validation without any modification that is impacted by a potentially tampered signal. |
| Samsung | As long as we study angular-based positioning techniques to serve as the supplemental information to resolve the mirror image ambiguity of the time-based positioning techniques, we are fine with that.  But we think that studying angular-based techniques as the stand-alone solution to provide accurate UE location within the given requirement will be waste of time. |
| MediaTek | We’re mainly fine with the moderator proposal.  To our understanding, the UE needs to pre-compensate delay before transmitting SRS. The UE-specific report needs to be transmitted for the SRS for gNB to estimate the RTT. |
| LG | Time domain measurement based approach can be prioritized. |
| ZTE | It can be further studied. However, the feasibility of UL-AoA method is questionable since the satellite antenna may not able to well estimate the angle. Hence, the timing based method can be considered with high priority than angle based method. |
| SONY | OK to further study.  We think that AoA-based techniques could potentially be used in conjunction with other techniques. |
| Huawei, HiSilicon | We think the current satellite assumption cannot support the angle-based positioning. We think time-based positioning should be prioritized over angle-based positioning. |

## Third round proposal 7

Based on the second round:

Some companies [ CATT, Apple, LG, ZTE, Huawei, HiSilicon] prefer to deprioritize the angle based position method.

On the feasibility of the method as pointed by some companies, from moderator’s perspective; different techniques for angle-based positioning can be used to estimate UE location depending on satellite antenna architecture (use of 2D Antenna array with different sub panels) and whether digital, analog or hybrid beamforming are used. Such method is being used in existing satellite system (including GEO). As mentioned above AoA based method might be affected by several defects which may have a significant impact on the achievable accuracy and its cost may also be an issue but still it can be used in combination with other methods.

Moderator encourage companies to consider also AoA for the evaluation. This method can be combined with other methods (e.g as part of ECID method). We have only one meeting left (November meeting) to conclude the study, RAN1 should start considering other methods that can be used jointly or alternatively to time based methods.

The Proposal 7 is for further discussion during 3rd round.

**3rd round Proposal 7:**

**RAN1 to further study DL/UL angle-based positioning techniques in NR NTN:**

* **Discuss the achievable location accuracy with the uplink angle of arrival techniques in NGSO and GSO based NTN deployment**
* **Evaluate SRS coverage for UL-AoA and study NTN environment impact (e.g. timing drift) on SRS**
* **Discuss whether enhancements are necessary to meet Network verified UE location requirements**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| Apple | We are still not convinced that the UL-AoA positioning techniques can be used alone in verifying UE location, especially in a single GSO scenario.  It seems that some proponent companies of this proposal think about the combination of UL-AoA with timing-based positioning techniques. For the sake of progress, we can keep it open for this combined scheme. However, we still think timing-based positioning techniques should be prioritized. Since the current timing-based positioning techniques are focusing on NGSO deployment, we should remove the GSO from the proposal to align with the timing-based positioning techniques.  Also, we are not sure why the second bullet is needed in the proposal. SRS is not only used in UL-AoA, but also used in timing-based positioning techniques.  Finally, we think the last bullet is the next step after study. It can be removed at this stage.  Hence, we have the following modification:  **RAN1 ~~to~~can further study UL angle-based positioning techniques in combining with timing-based positioning techniques in NR NTN:**   * **Discuss the achievable location accuracy with the uplink angle of arrival techniques in NGSO ~~and GSO~~ based NTN deployment** * **~~Evaluate SRS coverage for UL-AoA and study NTN environment impact (e.g. timing drift) on SRS~~** * **~~Discuss whether enhancements are necessary to meet Network verified UE location requirements~~** |
| Samsung | We should study angular-based positioning techniques, *only* *to serve as the supplemental information* for the time-based positioning techniques.  Also since the focus and the priority of discussions so far has been on LEO, we think it’s too early to discuss GSO UE positioning. So basically we agree with Apple’s modification to the proposal. |
| LG | AoA based technique can be deproritized. But, as a compromise, we can live with  Apple’s modification. |
| ZTE | Angular based method should have lower priority since it is questionable whether UL-AoA based solution can provide enough accuracy. Apple’s modification is more preferred by us. |

# Topic #8 Evaluation of NR NTN ECID positioning techniques

## Background

As per TR 38.882 recommendations, when considering solutions based on positioning methods, existing 3GPP defined RAT dependent positioning methods shall be considered as baseline. Other methods are not precluded.

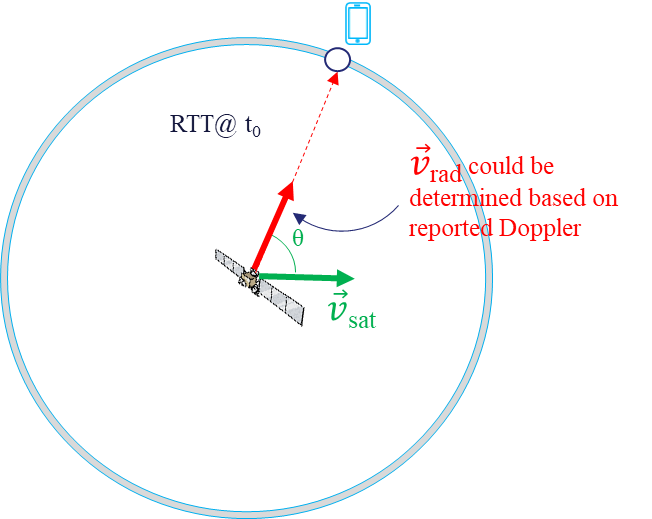
## Companies’ contributions summary

On the evaluation of NR NTN ECID positioning techniques, the following proposals were made by some companies :

|  |  |
| --- | --- |
| **Companies** | **Proposals** |
| Ericsson | Proposal 3 RAN1 to discuss the achievable accuracy with the angle of arrival method, and with the E-CID method based on measurements on the same satellite as well as hybrid combinations. |
| Nokia, Nokia Shanghai Bell | **Observation 2:** UE neighboring cells measurements can be a good indicator of the UE location relative to the orbital line.  **Proposal 2**: RAN1 to consider other measurement approaches than current standardized methods (e.g., Multi-RTT and DL/UL-TDOA) to solve the network verified UE position problem.. |
| Thales | Proposal 8: NR NTN UE should report the Doppler calculated on the service link.  Proposal 9: a VSAT UE beam pointing in respect to satellite beam line of sight  Proposal 10: RAN1 to discuss whether NR NTN Enhanced cell ID positioning methods could be used for UE location verification in NTN by considering appropriate NR E-CID measurements.  Proposal 11: RAN1 to determine the appropriate NR E-CID measurements that could be used to verify the location of the UE. These may include:   * UE reported measurements:   + UE specific Timing Advance   + Doppler calculated on the service link,   + SS-RSRP, SS-RSRQ, CSI-RSRP and CSI-RSRQ.   + For a VSAT UE beam pointing in respect to satellite beam line of sight. * gNB measurements:   + UL Angle of Arrival (azimuth and elevation) * RTT calculation:   + UE Rx-Tx time difference measurements of downlink signals   + gNB Rx-Tx time difference measurements, of uplink signals transmitted from UE |

## First round proposal 8

The feasibility of time based positioning methods (i.e. Multi-RTT and XL-TDOA) in case of single satellite is still under investigation. It is Moderator recommendation to investigate other potential techniques such as Angle of Arrival or **a combination of different methods e.g. UE Location verification based on RTT calculation (one RTT measurement)** and radial velocity reported by the UE as illustrated in the figure below:



Based on the above, the following proposal is made:

**Initial Proposal 8:**

**RAN1 to discuss whether NR NTN Enhanced cell ID positioning methods could be used for UE location verification in NTN by considering appropriate NR E-CID measurements.**

**Note: NR NTN ECID positioning allows combination of different methods e.g. UE Location verification based on RTT calculation (one RTT measurement) and radial velocity reported by the UE.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| QC | Companies can propose the specific methods. No need of the above agreement. |
| Apple | We prefer to focus on timing-based positioning techniques. |
| Xiaomi | We also suggest to focus on the timing-based positioning techniques unless there are problems that cannot be resolved. |
| Panasonic | OK for us. |
| vivo | This proposal is not necessary as timing-based method is already enough according the evaluations performed.  So ECID based methods can be deprioritized. |
| Nokia, Nokia Shanghai Bell | Nokia agrees that the use of several methods, input parameters can solve the UE location verification on network side. It however we need to be carefully design the solution to avoid creating too much overhead by sending too much information. |
| CATT | Support |
| LG | We don’t see the necessity of agreeing on this proposal. As agreed in RAN1#110, any method can be discussed.  Agreement  The following 3GPP defined RAT dependent positioning methods shall be considered as starting point for the study on Network verified UE location in case of NGSO based NTN deployment:   * Multi-RTT * DL/UL-TDOA   Note-1: Other methods (e.g. AoA based) are not precluded  Note-2: RAT independent positioning methods are not under the scope of the study |
| Lenovo | We support this study as NTN E-CID can be used in combination with timing based techniques. Especially this may be more relevant in case of earth moving beams. |
| OPPO | We suggest to look at existing positioning method instead of studying new combination method, unless the exisiting methods are proved to be not feasible. |
| MediaTek | Support proposal. As commented above for AoA solution, since UE needs to pre-compensate delay before transmitting SRS, the UE-specific report needs to be transmitted for the SRS for gNB to estimate the RTT for eCID. The indication of satellite radial velocity reported by the UE can be way to calculate the AoA in the gNB. This method should be discussed in RAN1 |
| NTT DOCOMO | This proposal is not needed as any methods is not precluded. Meanwhile, we think timing-based positioning techniques should be mainly focused on due to limited time. |
| Ericsson | We are ok with the proposal but it is not clear which of the methods can be combined e.g., the trustworthiness of the UE-report based methods is not yet clear. |
| SONY | It is unclear that NR NTN ECID can meet the positioning requirements, especially considering positioning based on a single satellite.  We are OK with considering a combination of measurements to perform location verification (e.g. timing based measurements + other measurements). |
| Huawei, HiSilicon | In our understanding, the requirement of UE location verification is hard to satisfy with ECID positioning as the cell size of NTN may be very large, and the measurement of RSRP/RSRQ has less help as the difference is small in NTN scenarios. Moreover, whether radial velocity report is reliable is still unclear to us,  We prefer to focus on time based solution first. |
| ZTE | The proposal seems too general, which may not be necessary. As mentioned by LG, the other methods are not precluded. Agreement is only needed when we want to preclude some solutions. |

## Second round proposal 8

The views expressed during the first round are quite diverse. Same as for AoA discussion some companies want to focus on timing-based positioning techniques.

Moderator’s view: Moderator wants to recall that as per previous RAN1 meeting other methods are not precluded. Also time based method with a single satellite in view may need to be combined with other methods at least to solve the ambiguity of the mirror image position. But also, to reduce the latency inherent to those time based method.

Some companies pointed out that the initial proposal is more general and it is not clear which of the methods can be combined. The proposal is updated to provide more details:

**Updated Proposal 8:**

RAN1 to determine the appropriate NR E-CID measurements that combined could be used to verify the location of the UE. These may include:

* UE reported measurements:
  + SS-RSRP, SS-RSRQ, CSI-RSRP and CSI-RSRQ.
  + For a VSAT UE beam pointing in respect to satellite beam line of sight.
* gNB measurements:
  + UL Angle of Arrival (azimuth and elevation)
* RTT calculation:
  + UE Rx-Tx time difference measurements of downlink signals
  + gNB Rx-Tx time difference measurements, of uplink signals transmitted from UE

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| OPPO | Low priority |
| CATT | Support |
| Panasonic | We agree. |
| Lenovo | Support |
| Apple | Low priority |
| Ericsson | Support |
| Nokia, Nokia Shanghai Bell | Support the intention of the proposal, but considering the potential load on the Uu interface it might be beneficial to allow for some of the UE reported measurements to be consolidated on the UE side prior to transmission in the UL. We would suggest to put a FFS as sub-bullet to the UE reported measurements which reads: “FFS: Methods to reduce the amount of data to deliver UE measurements”. |
| MediaTek | The UE-specific TA report should be also included as the gNB cannot measure the RTT from the SRS transmission. To our understanding, the UE has to pre-compensate the satellite delay before UL transmission of SRS. Other UE report could also be considered to help with the determination of the angle of arrival (e.g. satellite radial velocity derived by the UE based on ephemeris and GNSS). |
| LG | Low priority. |
| ZTE | We think time based method should be focused now. Of course it’s OK to further study combined solutions. But since previous agreement does not preclude other methods, there seems no need to agree on methods which are not well discussed. And we agree with MediaTek that TA report should be added in RTT-calculation is the proposal will be agreed. |
| vivo | Timing-based method should be verified and concluded first. We can come back to see the necessity of ECID when ready. Therefore, we think ECID based methods can be deprioritized at this stage. |
| SONY | Support |
| Huawei, HiSilicon | This should be low priority. |

## Third round proposal 8

Based on the second round:

Some companies prefer to deprioritize the NR E-CID method. And prefer that timing-based method should be verified and concluded first.

To the Moderator, this is not a good approach. Indeed, as long as the feasibility of timing-based method is not 100% proved, other methods should remain on the table and should be evaluated in parallel to the ongoing evaluation of time based methods. We have only one meeting left for the study.

**3rd round Proposal 8:**

RAN1 to determine the appropriate NR E-CID measurements that combined could be used to verify the location of the UE. These may include:

* UE reported measurements:
  + SS-RSRP, SS-RSRQ, CSI-RSRP and CSI-RSRQ.
  + For a VSAT UE beam pointing in respect to satellite beam line of sight.
* gNB measurements:
  + UL Angle of Arrival (azimuth and elevation)
* RTT calculation:
  + UE Rx-Tx time difference measurements of downlink signals
  + gNB Rx-Tx time difference measurements, of uplink signals transmitted from UE

**FFS: Methods to reduce the amount of data to deliver UE measurements.**

**FFS: Whether UE specific TA can be used as part of NR E-CID measurements for UE location verification.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| Apple | We do not think the last FFS is needed. Based on the discussion in Topic #5, we are not convinced that UE specific TA is trustworthy.  Also, we do not see why the methods to reduce the amount of data are necessary in the context of network verification of UE location. Hence, we suggest removing this FFS as well.  Finally, we still think the timing-based positioning techniques are the starting point, and we prefer only considering other schemes unless the timing-based positioning techniques cannot meet the requirements (e.g., latency requirement). |
| Samsung | Generally fine with the proposal. However, we believe it has low priority. The second FFS regarding UE specific TA is redundant and can be removed, since in Topic#5 we are still discussing whether or not it is reliable. |
| LG | Still, it can be considered as low priority. |
| ZTE | Open to consider hybrid solutions but should be low priority. |

# [CLOSED] Topic#9 UE Location verification during Initial access

## Background

As stated in the TR 38 882, clause 4.4 [2] most UE positioning functionality is typically UE-associated, i.e., it assumes that a UE context is present for the UE being positioned. This means that the UE itself has already completed the initial access procedures. Further, it is assumed that UE can only report GNSS location report after NAS security is established based on SA3 guidance. It is therefore assumed that UE is in RRC connected state in the procedure of network verifying UE’s reported location information.

During RAN1#110 there was no enough time to duly discuss this issue.

## Companies’ contributions summary

On Topic#9 the following proposals were submitted to RAN1#110bis.

|  |  |
| --- | --- |
| **Companies** | **Proposals** |
| Apple | **Proposal 1:** The network verifying UE location only occurs in UE’s RRC connected state. |
| InterDigital, Inc. | **Proposal 1:** Study achievable accuracy of IDLE mode positioning for NTN  **Proposal 2:** Study feasibility of IDLE mode positioning methods using SRS for positioning and/or PRACH  **Proposal 3:** Send an LS to RAN2 to prioritize IDLE mode positioning in RAN2 positioning and consider NTN based scenario (e.g., moving TRP) |
| NTT DOCOMO | **Proposal 6:**  Deprioritize the discussion on UE location verification during initial access. |

## Initial proposal 9

From moderator’s perspective, it might be beneficial for the NG RAN to have information about verified UE location during call setup and before transmitting the NGAP Initial UE message containing User Location Information (ULI). This may be needed e.g. for AMF selection. Therefore, UE Location verification during Initial access might be discussed otherwise, it would be necessary to handle the initial access from the UE, without the availability of the location verification. And consider a delayed action once the verification verdict is available to the network.

However, it seems that other WGs (RAN2 and RAN3) are considering the re-use of the LCS framework of the LMF for the network verification of UE reported location information in NTN. Which de facto means that UE location verification may be performed only at RRC connected state.

Therefore, it seem reasonable to deprioritize for now the discussion on UE location verification during initial access.

Based the above discussion, the following proposal is made:

**Initial Proposal 9:**

**Deprioritize the discussion on UE location verification during initial access.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| QC | OK |
| Apple | Agree |
| Xiaomi | Support |
| Samsung | Agree |
| Panasonic | OK |
| vivo | Fine. |
| Nokia, Nokia Shanghai Bell | We agree. Potentially request SA2 to facilitate a solution where a UE is disallowed/banned from the network due to failure to comply with the accuracy requirements. |
| CATT | OK |
| LG | Fine. |
| Lenovo | Agree |
| Intel | Agree |
| MediaTek | Agree. |
| NTT DOCOMO | Agree |
| Ericsson | Agree |
| SONY | OK. Other WGs can consider higher layer issues and RAN1 can come back to this based on the feedback from those other WGs, if any. |
| Huawei, Hisilicon | We support that the reporting procedures of the location verification taken by NW should be performed at RRC connected state. However, considering the delay of measurements we suggest further study on early measurement, e.g. before or during initial access to reduce the verification delay.  Regarding moderator’s point of RAN2 discussion of reuse LCS framework, we think that does not conflict our study for measurement during initial access. |
| ZTE | Agree |

The following agreement was made at the GTW session on October 12th:

**Agreement**

Deprioritize the discussion on UE location verification during initial access.

The issue is closed.

# [CLOSED] Topic#10 Network node responsible for the location verification

## Background

This issue is discussed for the first time in RAN1 in current meeting.

## Companies’ contributions summary

The following views were expressed with respect to Topic#10 :

|  |  |
| --- | --- |
| **Companies** | **Proposals** |
| Xiaomi | Proposal 1: Both the gNB and the AMF could be responsible for the location verification |
| Lenovo | Proposal 10: The network entity performing the UE location verification may be up to RAN2 and SA2 decision depending on the type of location service request. |
| Apple | **Proposal 4:** For network verified UE location with DL TDOA positioning method, the LMF based scheme is used.  **Proposal 3:** For network verifying UE location in NGSO scenario, gNB reports satellite ephemeris information to LMF.  **Proposal 5:** For network verified UE location with DL TDOA positioning method, the time differences between multiple DL PRS transmission instances need to be reported from gNB to LMF.  **Proposal 6:** For network verified UE location with UL TDOA positioning method, the time differences between multiple UL SRS transmission instances need to be reported from UE to LMF. |

## Initial proposal 10

[**Apple**] is considering the re-use of the LCS framework of the LMF for the network verification of UE reported location information in NTN. [**Xiaomi**] considers both the gNB and the AMF could be responsible for the location verification. For [**Lenovo**] this is not RAN1 discussions.

Moderator’s view: Network-verified UE location has been discussed at RAN3 #117-e meeting, it was agreed that [RAN3 #117-e Chair’s Notes]:

• The verification is performed in the CN.

• If the reported UE location is not correct, the CN will take necessary action and Rel-17 behavior can be kept as baseline.

To the Moderator understanding, the RAN3 agreements are fully consistent with the current LCS architecture and protocol flow recalled in Figure 1 below. Once the UE is connected, the AMF triggers the location services request toward the LMF, which processes it and returns the result to the AMF. The AMF can then take the necessary action.



Figure 1 Location service support by NG-RAN

Based on the above, initial Proposal 10 is made as follows:

**Initial Proposal 10:**

**RAN1 assumes that the verification for UE location in NTN is performed in the core network (5GC). Details on how the 5GC verifies the UE location is up to SA2.**

**NTN specific assistance data and information elements to be reported by UE and/or gNB for Network verified UE location will be identified by RAN1.**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| QC | Agree |
| Apple | Agree |
| Xiaomi | For the first sentence, although we think gNB verification can have some benefits from the latency point of view. This is not RAN1’s work scope so don’t know whether we need to make an agreement on this. |
| Samsung | We think that the first bullet is not necessary because this is not RAN1 scope and doesn’t help for RAN1 progress. For second bullet, we think that it is premature since we don’t know yet on whether any assistance data and information is needed or not on top of the positioning scheme TN provides. |
| Panasonic | We agree. |
| vivo | The assumption seems not necessary for RAN1 at this stage. RAN1 only needs to tell RAN2/SA2 which methods are enough to achieve 5 to 10km accuracy based on some assumptions used in the evaluation. RAN1 impacts should be minimized given this is RAN2 led work item and we have limited TU.  Whether and how 5GC should be involved in UE location verification procedure should be up to RAN2/SA2 discussions. |
| Nokia, Nokia Shanghai Bell | agree |
| CATT | agree |
| LG | Fine with proposal. |
| Lenovo | We agree with the proposal and moderator’s view. |
| Intel | We are not sure if this proposal is in RAN1 scope |
| OPPO | fine |
| MediaTek | Agree |
| NTT DOCOMO | OK |
| SONY | This does not seem to be in RAN1 scope. |
| Huawei, HiSilicon | Support this proposal. |
| ZTE | Fine with the proposal. But since RAN3 has already agreed the location is performed by CN, there is no need to say “RAN1 assume”. RAN1 only need to identify the information to be reported with RAN3 agreement. |

The proposal was discussed during the GTW on October 12th. Based on online session discussion it seems that the first sentence of the proposal is not essential (some companies argued that this is not the scope of RAN1)

The second sentence will be discussed when the design of the solution for the verification of UE location is clear. We will come back on this later on.

The issue is closed for now.

# [NEW] Topic #11 Error due the satellite movement between TX and RX measurements

## Background

As discussed in section 1, the UE position uncertainty is dependent on the RTT measurement accuracy. Such measurement should take into account the timing error but also satellite movement. For the study on the feasibility of multi-RTT based positioning method with a single satellite in view, RAN1 shall discuss the different sources of error on RTT computation and the achievable RTT measurement accuracy in NTN

## Initial proposal 11

Further evaluation results taking into account error due the satellite movement between TX and RX measurements should be provided.

**Initial Proposal 11:**

**For the evaluation of time based positioning methods, further evaluation results taking into account error due the satellite movement between TX and RX measurements should be provided.**

* **How this error is characterised is also reported by companies**

Companies are encouraged to provide views within the following table:

|  |  |
| --- | --- |
| **Companies** | **Comments and Views** |
| Apple | Agree.  Regarding the error characterization, we can assume a list of time difference values between DL reception and UL transmission. Then we can evaluate the resulting error under this assumption. |
| LG | Agree |
| ZTE | Fine with the proposal. And note that for TA report based method, the TA calculation has considered the satellite movement. No need to change TA calculation formulation regardless of the purpose. |

# Conclusion

TBC

# Appendix: Summary of proposals

|  |  |  |
| --- | --- | --- |
| **TDoc** | **Source** | **Proposals** |
| [**R1-2208389**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208389.zip) | THALES | Proposal 1: RAN1 to investigate whether TN positioning methods (e.g. OTDOA, Multi-RTT, DL-AoD, UL-AoA DL-TDOA and CID/NR E CID) could be adapted and used for the verification of UE location in case of only a single satellite is in view.  Proposal 2: RAN1 to send LS to RAN2/SA1 requesting inputs on the acceptable maximum latency to carry out the UE location verification procedure.  Proposal 3: RAN1 to discuss whether the UE location determination/verification could involve only a single cell or multiple cells within the same gNB.  Proposal 4: RAN1 should study angle-based positioning techniques in NR NTN:  Proposal 5: RAN1 to discuss the achievable location accuracy with the uplink angle of arrival techniques in NGSO and GSO based NTN deployment  Proposal 6: RAN1 should evaluate SRS coverage for UL-AoA and study NTN environment impact (e.g. timing drift) on SRS. For evaluation purposes, NR NTN SRS for Positioning reuses the Rel-16 NR sequence design and resource mapping as baseline.  Proposal 7: To enhance UL-AoA based positioning performance in NTN, consider auto-calibration process to compensate for satellite beam pointing error, this includes:   * Use of beacon uplink signals to adjust satellite beam pointing, * Zadoff-Chu sequence used for the SRS maybe beacon specifically configured as a potential solution to introduce such beacon signals in NR NTN with a minimum specification impact.   Proposal 8: NR NTN UE should report the Doppler calculated on the service link.  Proposal 9: a VSAT UE beam pointing in respect to satellite beam line of sight  Proposal 10: RAN1 to discuss whether NR NTN Enhanced cell ID positioning methods could be used for UE location verification in NTN by considering appropriate NR E-CID measurements.  Proposal 11: RAN1 to determine the appropriate NR E-CID measurements that could be used to verify the location of the UE. These may include:   * UE reported measurements:   + UE specific Timing Advance   + Doppler calculated on the service link,   + SS-RSRP, SS-RSRQ, CSI-RSRP and CSI-RSRQ.   + For a VSAT UE beam pointing in respect to satellite beam line of sight. * gNB measurements:   + UL Angle of Arrival (azimuth and elevation * RTT calculation:   + UE Rx-Tx time difference measurements of downlink signals   + gNB Rx-Tx time difference measurements, of uplink signals transmitted from UE |
| [**R1-2208396**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208396.zip) | MediaTek Inc. | **Proposal 1**: Support network-based UE location verification with multiple-RTT with prediction solution based on UE-specific TA report.  **Proposal 2**: RAN1 study finer than 1 ms granularity for UE-specific TA report via MAC CE.  **Proposal 3**: RAN1 study configuration of time interval between each UE-specific TA report to allow sufficient accuracy of the verification of the UE position in single satellite scenario. |
| [**R1-2208436**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208436.zip) | Huawei, HiSilicon | **Proposal 1:** Support reuse the existing reference signal (e.g. CSI-RS) for DL-TDOA and multi-RTT to minimize the resource overhead and UE power consumption due to UE location verification. |
| [**R1-2208663**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208663.zip) | vivo | **Proposal 1:**   * Reuse existing DL-TDoA method already specified in TN which is enough for UE location verification in NTN. |
| [**R1-2208694**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208694.zip) | ZTE | **Proposal 1:** 3D positioning methods should be applied even if 2D positioning error is the performance metric.  **Proposal 2:** Single-satellite based multi-RTT positioning method can be used for UE location verification for LEO.  **Proposal 3:** The earth moving beam case is deprioritized for single satellite based location verification.  **Proposal 4:** TA report based location verification method can be investigated as alternative to legacy multi-RTT positioning method.  **Proposal 5:** TA report with higher granularity can be investigated to improve the location verification performance.  **Proposal 6:** UE can be assigned with reliability flag based on verification result to reduce the frequency of location verification.  **Proposal 7:** Network will reject access from UE assigned with unreliable flag and accept access from UE assigned with reliable flag without location verification. |
| [**R1-2208835**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208835.zip) | OPPO | Proposal 1: RAN1 to send an LS to SA3 to ask for the confirmation on whether a TA reported by a non-trustful UE is considered to be trustful for positioning purpose.  Proposal 2: RAN1 to take DL-TDOA as a baseline method with higher priority. |
| [**R1-2208955**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208955.zip) | CATT | **Proposal 1:** The DL-OTDOA method with perfect time synchronization should be treated as the baseline, due to the less impaction in satellite rapid motion and SNR deterioration in UL compared with Multi-RTT method.  **Proposal 2:** The position of UE may be supposed on the surface of earth, and the horizontal position error can be defined as the distance between the actual UE position and the projecting point on the earth surface of the calculated UE position.  **Proposal 3:** For the DL-OTDOA method, the range of DL SNR is approximately from -3.51dB to 6.64dB both in LEO 600km and 1200km scenarios.  **Proposal 4:** The SNR is the major factor to impact the PRS timing measurement error in AWGN channel, and the evaluated results of accuracy of PRS measuring in NR RAT-dependent position methods can be reused in NTN scenarios.  **Proposal 5:** In LEO 600km scenario, the horizon position error can be achieved less than 10km above 97% by collecting 10 measurements in about 180s when the UE’s elevation angle is above 30º.  **Proposal 6:** In LEO 1200km scenario, the horizon position error can be achieved less than 7km above 100% by collecting 15 measurements in about 280s with the elevation angle beginning at 30º, meanwhile the total measuring time reduced to 120s with collecting 7 measurements to satisfy the accuracy when the elevation angle beginning with 60º. |
| [**R1-2209072**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209072.zip) | Intel Corporation | **Proposal 1**:  The following enhancements are considered to enable UL-TDOA for single satellite-based positioning   * Reporting of the TA values applied for each SRS transmission * Reporting of the TA value applied for the 1st SRS transmission and fixed TA for other SRS transmissions   **Proposal 2**:  The following enhancement is considered for DL-TDOA for single satellite-based positioning   * Reporting of RSTD values for multiple measurements of single PRS resource (periodic or semi-persistent) with a PRS transmission for the same PRS resource as a time reference   **Proposal 3**:   * For Multi-RTT positioning with single satellite, RX-Tx Time difference reported by the UE shall consider the autonomous TA applied by the UE |
| [**R1-2209115**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209115.zip) | Sony | **Proposal 1:** RAN1 should consider positioning measurement intervals for the chosen RAT-dependent positioning methods for the single satellite case.  **Proposal 2:** RAN1 should consider whether or not UE mobility should be taken into account.  Observation 1: A malicious UE intent on reporting a fake location can also report fake location verification measurements commensurate with its fake location.  **Proposal 3:** RAN1 shall define network location verification methods that are immune to spoofing by malicious UEs intent on reporting a fake location |
| [**R1-2209265**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209265.zip) | Xiaomi | **Proposal 1**: Both the gNB and the AMF could be responsible for the location verification.  **Proposal 2:** The RTT estimation error due to the movement of the satellite should be taken into account.  **Proposal 3:** The RTT estimation error on the feeder-link can be handled the gNB.  **Proposal 4:** The RTT estimation error on the service-link can be reported by the UE.  **Proposal 5:** The DL-TDOA solution is feasible to support the network verified location.  Proposal 6: The delay required for verifying the location needs to be further considered to avoid the impact to the service. |
| [**R1-2209398**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209398.zip) | Lenovo | **Proposal 1:** RAN1 to confirm that the network verification accuracy requirement is at least in the range between 5-10 km for NTN. FFS whether additional requirements need to be defined for other services, e.g., emergency services.  **Proposal 2:** RAN1 to further study enhancements (if needed) to both PRS/SRS configuration design for NTN RAT-dependent positioning techniques.  **Proposal 3:** RAN 1 to clarify if hybrid positioning methods (RAT dependent and RAT independent) are under the scope of study.  **Proposal 4:** RAN1 to further study DL-TDoA/UL-TDoA and Multi-RTT timing-based positioning techniques and associated adaptations for NTN to verify UE reported location  **Proposal 5:** For NTN network, UE position is determined based on the propagation delay differences between satellite(s) and UE.  **Proposal 6:** For NTN network, satellite positions for different time instances are useful to determine the propagation delay difference between satellite and UE.  **Proposal 7:** Further study application of Multi-RTT based solution to difference scenarios including GEO, LEO, HAPS.  **Proposal 8:** RAN1 to further study DL/UL angle-based and NR ECID positioning techniques and associated adaptations for NTN to verify the UE reported location.  **Proposal 9:** Characteristics for single satellite and multiple time instances should be taken into account when designing schemes for network to verify UE reported location.  **Proposal 10:** The network entity performing the UE location verification may be up to RAN2 and SA2 decision depending on the type of location service request. |
| [**R1-2209600**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209600.zip) | Apple | **Proposal 1:** The network verifying UE location only occurs in UE’s RRC connected state.  **Proposal 2:** In NGSO scenario, RAN1 to treat different satellite locations of the same NGSO satellite at different time instances as different gNB locations in terrestrial network positioning methods.  **Proposal 3:** For network verifying UE location in NGSO scenario, gNB reports satellite ephemeris information to LMF.  **Proposal 4:** For network verified UE location with DL TDOA positioning method, the LMF based scheme is used.  **Proposal 5:** For network verified UE location with DL TDOA positioning method, the time differences between multiple DL PRS transmission instances need to be reported from gNB to LMF.  **Proposal 6:** For network verified UE location with UL TDOA positioning method, the time differences between multiple UL SRS transmission instances need to be reported from UE to LMF.  **Proposal 7:** In NGSO scenario with multi-RTT positioning method, consider that the distance between satellite and UE at the time of downlink transmission is different from the distance between satellite and UE at the time of uplink transmission.  **Proposal 8:** In NGSO scenario with multi-RTT positioning method, do not support the scheme that RTT is obtained as the sum of UE reported total TA and the timing error of the uplink reference signal. |
| [**R1-2209643**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209643.zip) | InterDigital, Inc. | **Proposal 1:** Study achievable accuracy of IDLE mode positioning for NTN  **Proposal 2:** Study feasibility of IDLE mode positioning methods using SRS for positioning and/or PRACH  **Proposal 3:** Send an LS to RAN2 to prioritize IDLE mode positioning in RAN2 positioning and consider NTN based scenario (e.g., moving TRP) |
| [**R1-2209649**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209649.zip) | Ericsson Limited | [Proposal 1 UE reporting of timing advance cannot be trusted for the purpose of network-verified UE location in NTN.](#_Toc115422863)  [Proposal 2 Send LS to RAN plenary to seek a clarification on the interpretation of latency requirements and trust in UE RRC measurements (and if it is actually the RRM measurements that is meant instead of the RRC measurements). What measurements can be trusted? When and how often does the network need to verify the UE reported location? In case UEs shall be denied service until the UE reported location is verified by the network, what is an acceptable delay for the network verification procedure?](#_Toc115422864)  [Proposal 3 RAN1 to discuss the achievable accuracy with the angle of arrival method, and with the E-CID method based on measurements on the same satellite as well as hybrid combinations.](#_Toc115422865) |
| [**R1-2209751**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209751.zip) | Samsung | **Proposal 1:** The ambiguity of the mirror image position is resolved by very low resolution DL-PRS beamforming or UL angle of arrival determination.  **Proposal 2:** Study low resolution DL-PRS and low resolution UL angle of arrival determination to decide which one offers a more efficient solution for the ambiguity of the mirror image position.  **Proposal 3:** Single-satellite multi-RTT positioning method can be used for UE location verification for LEO constellation. The RTT measurements are performed by the same satellite at different time instances. |
| [**R1-2209922**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209922.zip) | NTT DOCOMO, INC. | **Proposal 1:**  Consider both single and multiple satellites scenario for verification of UE location in NTN.  **Proposal 2:**  For time-based RAT dependent positioning methods applied to NTN, study what additional information should be reported by UE and/or gNB to let LMF obtain the required results for positioning.  **Proposal 3:**  For time-based RAT dependent positioning methods in single satellite scenario,   * Multiple times of measurements are performed and reported with location information of the single satellite for each measurement.   **Proposal 4:**  For time-based RAT-dependent positioning methods, study impact on the movement of satellite.   * E.g., when the UE location is derived by gNB/LMF from propagation delays, determine the applied location of the satellite (i.e., a reference location of satellite) in order to eliminate/reduce the inaccuracy due to satellite movement.   **Proposal 5:**  For multi-RTT positioning method, consider applying UE/gNB Rx-Tx time difference measurements as baseline  **Proposal 6:**  Deprioritize the discussion on UE location verification during initial access. |
| [**R1-2210005**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210005.zip) | Qualcomm Incorporated | Proposal 1: Support TA report of an SRS transmission for network verification of UE location.  Proposal 2: RAN1 to identify NTN specific assistance data and information elements to be reported for Network verified UE location.  **Proposal 3**: For network verification of UE location, consider the following methods:   * Multi-RTT for single NGO satellites * DL TDOA with possible RTT for the serving satellite for multi-satellite case. |
| [**R1-2210050**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210050.zip) | Nokia, Nokia Shanghai Bell | **Proposal 1**: the UE reported location cannot be used in the network based UE location estimation.  **Proposal 2**: RAN1 to consider other measurement approaches than current standardized methods (e.g., Multi-RTT and DL/UL-TDOA) to solve the network verified UE position problem..  **Proposal 3:** RAN1 to consider to combine UE neighbor measurements to solve the ambiguity between mirror points. |
| [**R1-2210069**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210069.zip) | PANASONIC | **Proposal 1:** Adopt Multi-RTT as a method for network-based UE location verification.  **Proposal 2**: RAN1 should carefully consider the number of required RTT-measurements for multi-RTT. |
| [**R1-2210195**](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210195.zip) | LG Electronics | **Proposal #1:** Prioritize multi-RTT, DL/UL-TDOA for NW verified UE location. FFS on further down-selection.  **Proposal #2:** For RTT determination, option 1 is supported.   * Option 1: The multi-RTT positioning method makes use of the UE Rx-Tx time difference measurements of downlink signals (i.e. PRS) received from the satellite, measured by the UE and reported to the gNB and the measured gNB Rx-Tx time difference measurements, of uplink signals transmitted from UE (i.e. UL-SRS).   **Proposal #3:** If multi-RTT is selected as a baseline scheme for NW verified UE location, study at least followings   * How to handle timing error/delay due to processing time in satellite and movement of satellite and/or UE * Configuration of DL-PRS and SRS for the multiple measurement of UE Rx-Tx time difference |

# RAN1#110 Agreements

The following RAN1 agreements on Network verified UE location for NR NTN were made at RAN1 Meeting #110:

Agreement

The following 3GPP defined RAT dependent positioning methods shall be considered as starting point for the study on Network verified UE location in case of NGSO based NTN deployment:

* Multi-RTT
* DL/UL-TDOA

Note-1: Other methods (e.g. AoA based) are not precluded

Note-2: RAT independent positioning methods are not under the scope of the study

Agreement

For evaluating positioning performance in NTN, the following metrics apply.

* Horizontal accuracy:
* **Horizontal accuracy is the difference between a calculated horizontal position by the network and the actual horizontal position of a UE (for evaluation purposes)**
* **At least CDFs of horizontal positioning errors are used as a performance metrics in NR positioning evaluations**
* **At least the following percentiles of positioning error is analyzed 50%, 67%, 80%, 90%, 95%**

Agreement:

**The following parameters are assumed for the evaluation of RAT dependent positioning methods study in NTN:**

|  |  |
| --- | --- |
| **Parameter** | **Description/Value** |
| **Scenarios** | Rural, LOS |
| **Satellite Orbit** | 600km, optional: 1200km |
| **Satellite parameters** | Reuse Set-1satellite parameters as in table 6.1.1.1-1/2 of TR38.821 |
| **Channel model/ Delay spread** | Based on section 6.7.2 of TR 38.811 |
| **FR/Carrier frequency** | FR1: 2GHz, S-band (n256). Optional: FR2 |
| **BW** | To be reported by companies |
| **Subcarrier spacing, kHz** | 15 for FR1, optional: 120 kHz for FR2 |
| **Number of satellite in view** | 1 for single satellite case, |
| **Orbit inclination** | To be reported by companies |
| **UE type** | Handheld terminal, Optional: VSAT |
| **UE related parameters** | Handheld UE characteristics as in Table 6.1.1.1-3 of TR38.821 with update of polarization, Tx/Rx antenna gain, and antenna type and configuration as agreed under AI 9.12.1 |
| **Positioning signals (Note 1)** | To be reported |
| **Reference Signal Physical Structure and Resource Allocation (RE pattern)** | To be reported |
| **RS type of sequence/number of ports** | To be reported |
| **Number of symbols used per occasion** | To be reported |
| **number of occasions used per positioning estimate** | To be reported |
| **Time window for measurement collection** | To be reported |
| **Interference modelling (ideal muting, or other)** | To be reported |
| **Reference Signal Transmission Bandwidth** | To be reported |
| **Reference point for timing measurement** | Satellite |
| **Description of positioning technique / applied positioning algorithm** | To be reported |
| **UE speed** | 3km/h |
| **Maximum timing measurement error** | To be reported |
| **Performance metrics** | Horizontal accuracy (UE 2D position accuracy) |
| **Additional notes, if any** | Note 1: Time-related measurements can be performed via other downlink and uplink signals than PRS and SRS    Note 2: The corresponding link budget should also be reported and the verification procedure should be done within the restriction of minimum elevation angle for service, e.g., 30 degree for LEO |

# References

1. RP-222654, Revised WID: NR NTN (Non-Terrestrial Networks) enhancements, Thales
2. 3GPP TR 38.882, UE location for Non-Terrestrial-Networks (NTN) in NR (Release 18)
3. 3GPP TS 38.305 V17.1.0, Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN
4. R1-2208389 Discussion on network verified UE location in NR NTN THALES
5. R1-2208396 Network verified UE location for NR NTN MediaTek Inc.
6. R1-2208436 Discussion on network-verified UE location for NR NTN Huawei, HiSilicon
7. R1-2208663 Discussions on network verified UE location for NR NTN vivo
8. R1-2208694 Discussion on network verified UE location for NR NTN ZTE
9. R1-2208835 Discussion on network verified UE location for NR NTN OPPO
10. R1-2208955 Evaluations on network verified UE location for NR NTN CATT
11. R1-2209072 On network verified UE location for NR NTN Intel Corporation
12. R1-2209115 Network verified UE location for NR NTN Sony
13. R1-2209265 Discussion on the network verified location xiaomi
14. R1-2209398 NTN NW verified UE location Lenovo
15. R1-2209600 Discussion on Network Verified UE Location Apple
16. R1-2209643 UE location determination during initial access in NTN InterDigital, Inc.
17. R1-2209649 On network verified UE location in NR NTN Ericsson Limited
18. R1-2209751 Network verified UE location for NR NTN Samsung
19. R1-2209922 Discussion on Network verified UE location for NR NTN NTT DOCOMO, INC.
20. R1-2210005 Network verified UE location for NR NTN Qualcomm Incorporated
21. R1-2210050 Further discussion on Network Verified UE Positioning Nokia, Nokia Shanghai Bell
22. R1-2210069 Discussion on network verified UE location for NTN PANASONIC
23. R1-2210195 Discussion on network verified UE location for NR NTN LG Electronics