**3GPP TSG-RAN WG2 Meeting #119 electronic *R2-XXXXXXX***

**Online, August 17 - 26th, 2022**

**Agenda Item: 8.7.3**

**Source: Thales**

**Title: [POST119-e][108][R18 NR-NTN] NW verified UE location (Thales)**

**Work item Rel-18 NR-NTN-enh**

**Document for: Discussion**

# Introduction

This document aims to pursue the discussion around the agenda item 8.7.3 “*Network verified UE location*” of the 119-e RAN 2 meeting.

* [POST119-e][108][R18 NR-NTN] NW verified UE location (Thales)

Scope: discuss the main principles of the verification procedure (e.g. criteria, performance) and identify potential solutions considering proposals in contributions submitted to RAN2#119-e

Intended outcome: email discussion summary

Deadline: Long

The discussion will take place in 2 phases:

* A first phase to collect views on some proposals based on initial companies inputs: deadline for comments = FRIDAY 16th September 23:59 (UTC)
* A second phase for the moderator to prepare the summary based companies feedbacks: deadline for comments = FRIDAY 23th September 23:59 (UTC)

# Context

## 2.1 Recall of TR 38.882 recommendations

The verification should be performed independently from the location information reported by UE.

The UE location information for the study is considered verified if the reported UE location is consistent with the network based assessment to within 5-10 km (similar to terrestrial network macro cell size), enabling country discrimination and selection of an appropriate core network in order to support all the regulatory services (i.e. emergency call, lawful intercept, public warning, charging/billing).

The solution should not impact significantly the latency of the targeted services nor infringe privacy requirements that apply to the UE location.

The study in [RAN2,RAN1,RAN3], which will study and evaluate solutions for the network to verify UE reported location information, shall consider the following aspects:

- The scenario of single satellite (or HAPS) in view by the UE at a time is considered with higher priority.

- Multiple satellite (or HAPS) in view by the UE may be considered if time allows

- Assume that the UE is attached to a network (so that its context has been set up in the network) for the purpose of positioning

- Different solutions or positioning methods for NGSO, GSO or HAPS are not precluded

- When considering solutions based on positioning methods, existing 3GPP defined RAT dependent positioning methods shall be considered as baseline. Other methods are not precluded.

- Solutions using existing NG-RAN architecture and procedures shall be considered

## 2.2 List of TDOCs and related proposals submitted to RA2#119-e agreements on network verified UE location

|  |  |  |
| --- | --- | --- |
| [**R2-2207074**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207074.zip) | OPPO | Proposal 1 Satellite at a given time is considered as a TRP. Proposal 2 A moving satellite at multiple time instance is modeled as multiple TRPs.Proposal 3 TRP’s location is obtained through satellite’s ephemeris information.Proposal 4 Time difference between satellite-based TRPs should be under network’s control. |
| [**R2-2208775**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Inbox/R2-2208775.zip) | THALES | Proposal 0-1: The UE location information is considered verified if the reported GNSS position is consistent with the network based assessment to within 5-10 km (similar to terrestrial network macro cell size).Proposal 0-2: Given that the Network may determine multiple possible UE locations due to error/geometrical ambiguities, the reported GNSS position should be consistent with at least one of the multiple possible UE location.Proposal 0-3: The consistency may be based on a distance threshold (e.g. < 10 km) or a verification area as per implementationProposal 0-4: RAN2 should consider, as starting point, the re-use of the LCS framework of the LMF network for the network verification procedure.Proposal 1: UE assisted and network assisted methods can be considered as part of Network verified UE location study in RAN2 on the basis that UE reported information as part of 3GPP defined functions can be trusted if not derived exclusively from information provided by non 3GPP defined function.Proposal 2: The network verification of the UE reported location may combine one or several 3GPP defined RAT dependent positioning methods (e.g. Multi RTT, DL/UL-TDOA, DL-AoA, NR E-CID, etc.)..Proposal 3: The network verification procedure should not impact significantly the latency of the targeted regulated services (e.g. public warning system, lawful interception, emergency services, charging…).Proposal 4: The network verification procedure may be network triggered based on a command received from the network (AMF) or event triggered, after a given procedure such as RACH.Proposal 5: Wait for RAN1 outcomes on the performances in order to investigate further the multi-RTT solution at RAN2 levelProposal 6: a mono-RTT approach can be adopted for the GEO satellite caseProposal 7: Timing Advance (TA) value as applied by the UE (on the service link) in order to align the UL/DL subframe at the gNB air interface can be reported through a RRC message along with the frame/subframe number associated to TA value.Proposal 8: The precision of the Timing Advance (TA) reported value (as applied by the UE on the service link) needs to be further investigated. RAN2 should send an LS to RAN1 about the performance of the technique in a single satellite context.Proposal 9: Wait for RAN1 outcomes on the performances in order to investigate further the positioning method based on the Timing Advance (TA) value reporting (as applied by the UE on the service link) at RAN2 level |
| [**R2-2207274**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207274.zip) | Intel Corporation | Proposal 1: RAN2 to confirm NG-RAN assisted positioning methods (NR-ECID, UL-TDOA, UL-AoA) can be considered as network based assessment.Proposal 2: RAN2 to discuss whether UE assisted/LMF based positioning methods (DL TDOA, DL-AoD, Multi-RTT) can be considered as network based assessment, or whether the information from UE can be trusted.Proposal 3: For NTN positioning, RAN2 sends a LS to RAN1 and asks whether the accuracy of NR E-CID measurements can meet the requirements.Proposal 4: send a LS to RAN1 and ask whether the UL-AoA and DL-AoD positioning methods can still be feasible in NTN scenario.Proposal 5: send a LS to RAN1 and ask whether “single satellite (or HAPS) in view by the UE at a time” can be considered as a TRP when applying DL-TDOA/ UL-TDOA positioning methods.Proposal 6: send a LS to RAN1 and ask whether Multi-RTT positioning method can be applied in NTN.Proposal 7: RAN2 to consider reusing TA reporting for the purpose of network verified UE location.Proposal 8: the potential enhancements could be RAN transfers the TA value to LMF, or RAN2 needs to consider reporting TA value in LPP message. |
| [**R2-2207296**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207296.zip) | NEC Telecom MODUS Ltd. | Proposal 1: RAN2 discuss and clarify the expected level of maliciousness of UEs and their capacity to tamper UE locationProposal 2: Network verified UE location should not be used automatically for every UE reported location Proposal 3: If a method used by the network is not contradictory with the location provided by the UE, then the latter should be trusted by the network Proposal 4: After passing a verification following a network verified location, the location provided by the UE should only be trusted for a period of time. |
| [**R2-2207302**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207302.zip) | MediaTek Inc. | Proposal 1: Multi-RTT method with UE using its location and the satellite ephemeris to calculate and report the UE-specific TA to the network at different times over a verification period of a few seconds is the baseline for network-based UE location verification. |
| [**R2-2207326**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207326.zip) | Nokia, Nokia Shanghai Bell | Proposal 1: The verification method should be performed independently from the location information, reported by the UE (coarseLocationInfo). The NW does not need to wait for coarseLocationInfo reporting to begin its assessment.Proposal 2: NW assesses two-dimensional UE location when it verifies UE’s geo-position.Proposal 3: The extra latency introduced by the UE position verification should be kept as short as possible and should be below 1 s. More accurate value is FFS.Proposal 4: RAN2 considers UL-TDOA and DL-TDOA based methods to be applied with specific modifications for NTN.Proposal 5: RAN2 considers also other relevant methods, like Multi-RTT and angle of arrival.Proposal 6: RAN2 asks RAN1 to study how DL-TDOA, UL-TDOA, multi-RTT or angle of arrival methods can be used for network verification of the user location. Proposal 7: RAN2 provides RAN1 with the responses to the questions discussed within section 2 and 3 of this paper.  |
| [**R2-2207444**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207444.zip) | Apple | Proposal 1: Confirm the RAN2 work focuses on the existing RAN mechanism for the UE reported location verification. Proposal 2: Confirm the country level discrimination for UE location verification is sufficient. Proposal 3: NTN NW can identify the UE located country via the serving beam for the UE dedicated transmission in case each beam covers only one country. Proposal 4: From the signaling and NW architecture perspective, the existing NR positioning method can work well to verify the UE reported location.Proposal 5: Evaluation on the positioning performance including using single satellite case should be studied in RAN1 first. |
| [**R2-2207482**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207482.zip) | Huawei, HiSilicon | Proposal 1: RAN2 to agree that the UE location verification is done by LMF by reusing the legacy LCS procedures.Proposal 2: Send an LS to SA2 to ask if there is any issue with RAN2 conclusion.Proposal 3: RAN2 to further discuss which positioning method can be used to verify UE location. |
| [**R2-2207634**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207634.zip) | vivo | Proposal 1: For the scope of UE location verification, RAN2 confirms which of the following WFs to go by taking into account their pros and cons: - WF1: Enhance existing positioning method(s) in NG-RAN (TS 38.305) on top of the verification mechanism based on the LCS framework (already supported in R17 NTN); - WF2: introduce RAN-based verification methods, which can be supported independently by RAN (w/o dependency on legacy LCS framework). Proposal 2: Send LS to RAN1, informing RAN1 of the RAN2 conclusion on which WF to adopt, and asking RAN1 to carry out the study on the enhancements to POS methods in NG-RAN that are needed for this NTN-specific NW verification purpose (e.g. RS type, measurement to report, TRP aspects, etc.). |
| [**R2-2207645**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207645.zip) | China Telecom | Proposal 1: RAN2 evaluates TDOA and multi-RTT methods for network verified location in NTN.Proposal 2: Introduce the indication of NTN network verified UE location purpose in measurement configuration and report. |
| [**R2-2207675**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207675.zip) | Spreadtrum Communications | Proposal 1: gNB should verify the UE location.Proposal 2: gNB shall inform AMF to trigger the traditional position procedure. |
| [**R2-2207779**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207779.zip) | Samsung R&D Institute UK | Proposal 1: The network-based location verification solution uses assistance information from CN to verify UE-generated location information.Proposal 2: RAN2 send an LS to SA2 for feedback on potential assistance information from CN to aid in Network verified UE location via NWDAF analytics. |
| [**R2-2207866**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207866.zip) | Lenovo | Proposal 1: RAN2 to confirm that the network verification accuracy requirement is at least in the range between 5-10 km for NTN. FFS whether additional accuracy requirements need to be defined for other services, e.g., emergency services.Proposal 2: The single satellite case has been prioritized based on the conclusions of the TR 38.882, and further study is required regarding the impact to the overall positioning procedures, e.g., the types of positioning methods to perform NTN RAT-dependent positioning to assist in the verification process. RAN1 coordination may be required.Proposal 3: RAN2 to further study in coordination with SA2 on which of the network entities which may trigger, initiate, and perform the network UE location verification procedure, e.g., using the NI-LR LCS procedure. Send LS to SA2.Proposal 4: RAN2 to support low latency network verification procedures taking into account the extended propagation delays of NTN by considering at least the following:• Mechanisms to reduce LCS NG-RAN and core network signalling, e.g., identifying the need and benefits of supporting a local LMF in the NTN NG-RAN.• Identify the frequency of the network verification procedures to avoid unnecessary/redundant triggering of the verification. • Identify the validity of the provided verified network UE locationProposal 5: RAN2 to consider RAN-based solutions for UE location verification purposes in coordination with the RAN1.Proposal 6: Study the impact on UE location verification using different multi-connectivity NTN architectures on positioning procedures and verification procedures, e.g., including the use of multi-satellites or TN and NTN connectivity scenario.Proposal 7: In case of a mixed multi-connectivity scenario involving TN NG-RAN and NTN NG-RAN, the verification procedure does not involve NTN NG-RAN and can be based on the UE cell-ID of TN NG-RAN. |
| [**R2-2207915**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2207915.zip) | Xiaomi | Proposal 1: Both NG-RAN and core network to verify the UE location should be considered.Proposal 2: RAN2 confirms that the existing 3GPP RAT dependent positioning methods shall be considered as baseline for UE location verification.Proposal 3: The RAT-dependent positioning including DL-TDOA, UL-TDOA and multi-RTT should be considered for UE location verification.Proposal 4: For gNB verifying the UE location, the gNB triggers the LMF to perform the RAT-dependent positioning procedure.Proposal 5: For the NGSO, the RAT-dependent positioning only involved the gNB and UE can be considered for UE location verification. |
| [**R2-2208022**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2208022.zip) | Deutsche Telekom, Huawei, HiSilicon | Proposal 1: RAN2 to investigate whether and how the NTN network can instruct the UE to report reference TN PLMN identities for UE location verification.Proposal 2: RAN2 to take this solution into consideration when evaluating the need for Network verified UE location specification support in Rel-18. |
| [**R2-2208328**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2208328.zip) | NTT DOCOMO INC. | Proposal. RAN2 wait for RAN1 and start discussion on signalling for network verified UE location upon RAN1 have listed candidate solutions or concluded specific solutions. |
| [**R2-2208376**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2208376.zip) | CATT | Proposal 1: RAN group level study on UE location verification should follow the recommendation of the RAN level study as specified in the TR 38.882.Proposal 2: Exchange of TRP info between NG-RAN and LMF may need to be adjusted due to the moving of the TRPs, the details could be left to WI phase.Proposal 3: Wait for SA2 and RAN3 to decide which node is responsible for UE location verification, NG-RAN or 5GC.Proposal 4: For LEO case, whether and how to support the positioning procedure during inter-cell, inter-satellite handover should be further discussed.Proposal 5: Solutions for LEO case should be prioritized, GEO, HAPS cases could be deprioritized.Proposal 6: Existing positioning methods, e.g. ECID, UL/DL TDOA, UL/DL AOA, could be considered for UE location verification. The details should be evaluated in RAN1 firstly.Proposal 7: RAN2 should discuss if implementation based solution in NG-RAN is possible for UE location verification. |
| [**R2-2208444**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2208444.zip) | CMCC | Proposal 1: existing 3GPP defined RAT dependent positioning methods, e.g., UL/DL TDOA, UL/DL AOA, multi-RTT can be considered as baseline.Proposal 2: it is propose that RAN2 start to perform the normative work of signalling framework/flow design of RAN based positioning method for the UE location verification in NTN scenario.Proposal 3: it is proposed to limit the network based assessment in the granularity of 5-10 km, which is similar to TN macro cell size and study the solutions of reporting the TN cell information or Virtual Cell detected by UE.Proposal 4: If a given UE is regarded as malicious, as the reported location information is always “fake”, it is reasonable for the gNB to trigger the UE release procedure and recall the resource allocated to the UE. Proposal 5: the gNB can distribute and share the UE’s credit status according the maintained verification result for the UE to neighbour gNBs or CN. |
| [**R2-2208546**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2208546.zip) | ZTE Corporation, Sanechips | Proposal 1: RAN2 prioritize single satellite (or HAPS) scenarios in NW verified UE location discussion.Proposal 2: RAN2 to further study below options as candidate solutions for NW verified UE location in NTN:* Opt1: UE Rx-Tx time difference measurement in different time instance for single satellite scenario
* Opt2: TA report with potential enhancements to allow multiple TA report

Proposal 3: RAN1’s confirmation is needed to evaluate whether options in P2 can fulfilled the accuracy requirement.Proposal 4: UE can be tagged with reliability flag based on verification outcome to help reduce the frequency of verification procedure. |
| [**R2-2208674**](https://www.3gpp.org/ftp/TSG_RAN/WG2_RL2/TSGR2_119-e/Docs/R2-2208674.zip) | Ericsson | Proposal 1: RAN2 to investigate the achievable accuracy of the angle of arrival method, and of the E-CID based on measurements on the same satellite as well as hybrid combinations.Proposal 2: The UE can be provided an IDLE mode measurement configuration for NW location verification, measurements are delivered to the NW after security have been enabled. |

For the 119-e RAN 2 meeting, companies made the above proposals. Some of its proposals are already covered by recent agreements that can be found in the next section 2.3.

## 2.3 RAN1#110 agreements on network verified UE location

Agreements:

1. 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

1. 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%

1. The following parameters are assumed for the evaluation of RAT dependent positioning methods study in NTN: *(see Annex 6.1)*

## 2.4 RAN2#119-e agreements on network verified UE location

Agreements:

1. The UE location information is considered verified if the reported GNSS position is consistent with the network based assessment to within 5-10 km (similar to terrestrial network macro cell size) (it is assumed that there is no RAN2 spec impact due to this)
2. RAN2 should consider, as starting point, the re-use of the LCS framework of the LMF network for the network verification procedure. Send an LS to SA2 indicating RAN2 assumption on this
3. The network verification of the UE reported location may combine one or several 3GPP defined RAT dependent positioning methods (e.g. Multi RTT, DL/UL-TDOA, DL-AoA, NR E-CID, etc.).

LS sent to SA2 (R2-2208779):

“RAN2 is considering the re-use of the LCS framework of the LMF for the network verification of UE reported location information in NTN.

RAN2 would like to inform SA2 about this agreement and ask for any related feedback.”

## 2.5 RAN3#117-e agreements on network verified UE location

Agreements:

1. The verification is performed in the CN.
2. If the reported UE location is not correct, the CN will take necessary action and Release-17 behavior can be kept as baseline. FFS on new cause value.
3. RAN3 wait for RAN1/2 progress on the specific position method to be used for verification.

# Discussion (1st round)

There are issues and proposals which were not resolved in RAN2#109e due to time-limited discussion and due to a lack of main principles accepted by the participants.

## 3.1 Verification procedure

## 3.1.1 Purpose

Reading the proposals listed in the 2.2 section, it is not clear yet what the verification UE location procedure aims to.

* **Opt1**: An alternative procedure of location for the CN with lower accuracy requirements than GNSS (i.e. 5-10 km). This option is based on Nokia R2-2207326 P2, Lenovo R2-2207866 P1, CMCC R2-2208444 P3.
* **Opt2**: A procedure to confirm that the UE GNSS position reported is located in given areas (i.e. in calculated areas defined by a geometric path or points with uncertainty of 5-10 km). This option is based on Thales R2-2208775 P0-2
* **Opt3**: A procedure used only for geographic country discrimination (i.e. assuming that an UE is verified if the cell beam cover only a country). This option is based on Apple R2-2207444 P2 and P3.

In R2-2208775, Thales highlights that in some cases the gNB could have several possible positions. For example with a multi-RTT approach in the case of a single satellite at different time step (*Figure 1: multi-RTT solution)* or in the GSO case (*Figure* 2: mono-RTT solution).

|  |  |
| --- | --- |
| Figure 1: multi-RTT solution | Figure 2: mono-RTT solution |

In R2-2207444, Apple seems to agree with Opt3 and asks whether or not country discrimination is sufficient.

**Question 3.1.1-1 : Please provide your recommended ranking on the below options as purpose of the verification procedure.**

* **Opt1**: Provide a UE location with a lower accuracy (i.e. 5-10 km) than GNSS.
* **Opt2**: Confirm that the UE GNSS position reported is located in a given area (i.e. defined by a geometric path or points with uncertainty of 5-10 km).
* **Opt3**: Provide only geographic country discrimination (i.e. assuming that an UE is verified if the cell beam cover only a country).

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| Thales | Agree with option 2 | Option 1: We think that it is challenging to perform a location procedure with only satellite within a short duration and able to provide a 5-10km accuracy.Option2: We think it is important to define flexible methods . Best case scenario, we can compute an accurate UE location. Worst case scenario (i.e. complex geometry, lake of information,…), we have a way to define areas in which the UE could be located. Option 3: We’re not opposed if the purpose of the verification procedure is only to verify (not to locate). |
| Hispasat | Option 2 | Ranking: Option 2, Option 1, Option 3. Scope should focus on the verification of an existing more exact location, which may also include the proper positioning as per in Option 1. Option 2 is preferable for simplicity; complete location may require higher resources and delays which may affect services. Option 3 does not cover the expected services, only CN/Operator selection. |
| vivo | Option 1 | We think Option 1 should be in the right way, and it is in line with current RAN1 progress on evaluating/selecting a POS method with acceptable positioning accuracy for this verification purpose.For Option 2, we understand it still requires NTN to acquire a UE location via related POS method by the NW itself (as in Option 1), and then judge how much the location acquired deviates from the given area, when UE reported GNSS info is regarded as not trusted. However, we wonder what Spec impact is needed for such judgement on the deviation from given area as indicated in Option 2, and whether it can be up to NW implementation. This further depends on which NW node is supposed to judge the deviation and do the verification, and also relates to whether there is a need for the location info to be transferred between RAN and LMF. Note that in Rel-17 SA2 already decided that LMF will not provide UE location info to the RAN, making such verification at RAN impossibly achieved. Therefore, we wonder how Option 2 above actually works, and would like to focus on Option 1 first before getting clear on all necessary details needed by Option 2. |
| CATT | Option2 | Option 1 is not the purpose, it’s just part of the verification procedure.Option 2 is aligned with the WID, the purpose of the UE location verification is to verify whether the reported UE location info is reliable or not. RAT dependent positioning mechanism(s) may be adopted, for which 5-10km accuracy is sufficient for verification.Option 3 is a kind of requirement or use case of the location verification, cross country discrimination could be achieved by the option 2. And the option 2 could also be applied for any other use cases. |
| Xiaomi | Option 2 and Option 1 | We think the option 2 aligns with the WID and option 1 also can be supported if Option 2 is agreed.   |
| OPPO | Option 2 |  |
| Docomo | Option 2 | Preference: Option 2 > Option 1 > Option 3.Option 1: Aren’t proponents of Opt1 intending to use the provided UE location for “confirming that the UE GNSS position reported is located in a given area”(Opt2)..?Option 2: Most aligns with the recommendation by TR 38.882.Option 3: We understand Apple (R2-220744) provided this purpose as that only in case NTN cell does not cover multiple countries, thus it is not appropriate to extend this purpose to be also applied to multi-country coverage case. (Note that it was SA2 that raised an issue of potential multi-country coverage, so we cannot revert this.) |
| ZTE | Option 2 | Share similar views as CATT, the intention of UE location verification is to see if UE reported GNSS can be seen as valid with the uncertainty of 5-10km as stated in option 2. And option 3 is one of the use case that can be considered. |
| Huawei, HiSilicon | Option 2 | Agree with CATT. |
| Nokia | Option 1 | Network verified location is needed to detect wrong position reporting from the UE, therefore we cannot use the position reported by the UE and the network need to find the area with 10 km accuracy where the UE is and then it can be compared with the position of the UE. Option 3 proposes to detect it only on country borders, but that would still mean a method with accuracy 5-10 km is required, so in fact that does not differ from option 1.  |
| Samsung  | Option 2 |  |
| Qualcomm | Option 1 or 2 | It can be just up to network how it verifies with option 1 or option 2. What AMF needs is an indication whether the UE location can be trusted with accuracy of 5km (or 10km which in fact too large).In our understanding option 3 is not a solution. The solution we need is when the cell is covering multiple boundaries. |
| Ericsson | None | There is no need to discuss **“purpose of the verification procedure”**, the TR is very clear in its recommendations:In this study, we have identified the need to define a network based solution which aims at verifying the reported UE location information.The verification should be performed independently from the location information reported by UE.The UE location information for the study is considered verified if the reported UE location is consistent with the network based assessment to within 5-10 km (similar to terrestrial network macro cell size), enabling country discrimination and selection of an appropriate core network in order to support all the regulatory services (i.e. emergency call, lawful intercept, public warning, charging/billing).The yellow part is the conclusion of the RAN plenary SI, green part gives a condition that verification shall be independent of location reported by the UE. The turquoise part gives the condition that if network based location differs from UE reported location with less than 5-10 km, then the UE location is considered to be verified. While the pink part only gives examples of why verification is needed.  |
| Intel | option 1 | According to the RAN plenary recommendation, the verification means network needs to calculate the UE location itself, then to compare with the UE location reported by UE. |
| Apple | Option 3 (proponent)Can accept Option 2 | We feel the discussion on purpose is not very necessary as it is already clear from the TR. |
| Lenovo | Option 2  | The mention of P1 (Lenovo R2-2207866) was meant to emphasize whether further study is required for other services, e.g. emergency services as the accuracy requirements of 5~10 km defined in TR38.882 may not be sufficient for some emergency services as defined by regulatory agencies e.g., FCC define accuracy of 50 m horizontal accuracy for E911 calls. We still support the verification of the UE reported GNSS as defined in Option 2, however we can further discuss the details of Option 1. |

Moderator summary

Most of companies agreed with option 2 although several recommend to adopt option 1

Some companies don’t see the need to discuss about the purpose which is already stated in the TR 38.882. In particular the network based solution shall be defined with the two following conditions

* The verification (of the reported UE location information) should be performed independently from the location information reported by UE.
* The UE location information for the study is considered verified if the reported UE location is consistent with the network based assessment to within 5-10 km

Hence it is proposed that

* The network shall be able to compute a possible UE location with uncertainty area independently from the location information reported by UE.
* The network (5GC) shall implement a method to verify the consistency (within 10 km) between the actual reported UE location with the UE location/its uncertainty area computed by the network

On the basis of the above, the moderator suggests

**Proposal 1: The network shall be able to compute a possible UE location with uncertainty area independently from the location information reported by UE.**

**Proposal 2: The network (5GC) shall implement a method to verify the consistency (within 10 km) between the actual reported UE location with the UE location/its uncertainty area computed by the network**

## 3.1.2 Triggering

RAN2 agreed to consider re-using, as starting point, the LCS Framework of the AMF/LMF network for the network verification procedure. This does not exclude discussing other ways to trigger verification. Also, it is not decided where the verification calculation are performed (i.e RAN or CN).

In R2-2207915, Xiaomi submitted the following proposal : “*Both NG-RAN and core network to verify the UE location should be considered.”*

In R2-2207675, Spreadtrum Communications supports that the gNB should verify the UE location.

**Question 3.1.2-1: Should an additional request from LMF to RAN be introduced in the NRPPa protocol to trigger the UE location verification ?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| Thales | Agree |  |
| Hispasat | Agree |  |
| vivo | No | In current Rel-17 Spec, it is AMF that triggers the LCS procedure for such NTN specific verification purpose. This question is also related to which NW node finally performs the verification, which should be decided first. Currently, we fail to see why the legacy way (i.e. AMF initiation) cannot work, and why a new trigger as proposed above has to be introduced.  |
| CATT | Disagree | According to the agreement achieved in RAN3#117-e.

|  |
| --- |
| The verification is performed in the CN. |

The entity to perform location verification is already decided by RAN3, there is no need to discuss this question in RAN2 again. |
| Xiaomi | Disagree | For the NG-RAN to verify the UE location, we think the request from RAN to LMF in the NRPPa to trigger LCS procedure is needed. |
| OPPO | No | We are confused about the question. Shouldn’t it be “from RAN to LMF” if the intention was to have RAN verify location (i.e. RAN as LCS client)? So far, we think the baseline assumption is sufficient, i.e. CN to trigger the procedure. |
| Docomo | Disagree | Same view as CATT. |
| ZTE | See comments | The question is not clear to us, if the question is to ask whether to introduce verification procedure at RAN in addition to what we have agreed (i.e., reusing existing LCS frame work) then the answer is no since there are no clear motivation to do so in RAN2.But since RAN might need to configure UE to report assisting information for location verification, then depending on the methods selected, signaling (new or updates of existing signalling) from LMF to RAN might be needed to inform RAN to do the configuration. It is too early to make decision at this stage.  |
| Huawei, HiSilicon | Disagree | RAN3 made the conclusion that it should be CN to perform the verification. So legacy procedure can be reused. We don’t see the necessity of introducing enhancements between LMF and RAN. |
| Nokia | Agree on the triggering |  |
| Samsung  | Disagree  | Same view as CATT. RAN3 agreed that “the verification is performed in the CN.” |
| Qualcomm | May be | We can also wait first to see in which direction the solution is going. At least for now it is between AMF and LMF.But we agree some change in NRPPa protocol may be needed to obtain assistance information such as serving satellite information. |
| Ericsson | Disagree | It is too early to decide. RAN2 do not necessarily need to follow RAN3 decision if RAN based solutions (that may or may not use a request from LMF to RAN) are deemed to be better.  |
| Intel | Disagree | same view with CATT. |
| Apple | Disagree | We share the understanding of CATT. |
| Lenovo | Disagree | Our understanding that we could further study LCS verification procedure which is triggered by the CN as specified in TS 23.501 sec 5.4.11.4.  |

Moderator summary

Most companies disagree and hence the moderator suggests to close the discussion for the time being.

**Question 3.1.2-2: Please share your views on other ways to trigger a verification procedure ? (e. g. RAN related event )?**

|  |  |
| --- | --- |
| **Company** | **Comments/Suggestions** |
| Thales | An early triggering of the verification procedure on the RAN side to reduce the possible latency may be studied (for example, the RAN could start to collect information to verify the UE location just after a UE has been attached). |
| Hispasat | RAN events (change of serving cell, coverage modifications…) may be considered. |
| Xiaomi | RAN can trigger the UE location verification when RAN acquires the UE GNSS location. |
| Nokia | The core network, LMF can prepare the relevant triggers for RAN hence early trigger can happen when desired. |
| Samsung  | RAN may trigger the UE location verification at the CN (e.g. RAN indicates to AMF to verify the UE location information.) |
| Ericsson | Only the CN knows whether the UE’s access is an initial Registration (corresponding to Attach in LTE), so it seems likely that a trigger/request from the CN would be good to have.  |
| Apple | Since the motivation of having UE location verification is to meet the regulatory requirement for certain services, it is more straightforward to let CN to trigger the verification procedure upon service initiation (or at other time points when needed). |
| Lenovo | We also share the view that the CN should trigger the procedure including receiving the UE reported GNSS position and performing the subsequent procedure of verification of this reported GNSS, e.g., AMF and/or LMF. |

Moderator summary

Most companies recommend that the verification procedure can be triggered by the CN any time after initial registration. Hence the moderator suggests the following:

**Proposal: It is assumed that the verification procedure can be triggered by the CN any time after initial registration**

## 3.1.3 Reuse of Location Services

RAN2 agreed to consider re-using, as starting point, the LCS Framework of the LMF network for the network verification procedure.

In R2-2208444, CMCC proposes that RAN2 start to perform the normative work of signaling framework.



Figure 3: Location Service Support by NG-RAN (TS 38.305, Figure 5.2.1)

NG-RAN and UE rely respectively on LPP and NRPPa protocols to perform the exchange of data necessary for positioning methods with LMF (see TS 38.305).

Currently LMF does not support combinations of positioning methods. RAN could also perform part of computations of positioning methods. RAN might not have all the information from the UE to perform verification calculations since the information is centralized at the LMF level.

**Question 3.1.3-1 : Should RAN performs additional processing to support the LMF in the verification of the UE location (e. g. combination of several positioning methods).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| Thales | Agree |  |
| Hispasat | Agree |  |
| vivo | No | It is unclear what such “combination” actually refers to. Also, RAN1 has not decided to consider any forms of combinations in their evaluation, so the feasibility or any detail of such “combination” has not been justified. At least the feasiblity and necessity for such “combination”should be evaluated first by RAN1, perhpas after evaluation on each single POS method on the table. |
| CATT | Only if needed. | This question can be discussed only if the positioning methods have been determined. However, at present, there is no agreement on using combination of several positioning methods for location verification, that the legacy processing seems enough. |
| Xiaomi | Disagree | The legacy LCS procedure already supports combination at some level, and whether the enhancements are needed or not should be evaluated by RAN1. |
| OPPO |  | Not clear what kind of additional processing is referred here. We don’t see why LMF cannot combine multiple positioning methods. |
| ZTE | Requires RAN1 input | Based on existing RAN2 agreements combination of multiple methods is one of the candidate solutions which is also now under assessment by RAN1.  |
| Huawei, HiSilicon | Wait for RAN1 | Similar view with ZTE.The combination of multiple methods is not agreed yet. It is just one of the possibilities. We should wait for RAN1’s evaluation first. |
| Samsung  | Disagree | Similar view to other companies. Support of a “combination”, if needed, should be discussed in RAN1. |
| Qualcomm | Maybe | For LMF, there should be a triggering point for verification. If verification is needed and the AMF is not able to verify UE from just a single method, it should be able to initiate another method to verify.But what is the scope of RAN in verification is not clear as we have sent LS to SA2 on AMF being responsible for verification and SA2 is also discussing issue. |
| Ericsson | Disagree | Too early for RAN2 to discuss, we can wait RAN1 evaluation of the methods locate the UE. |
| Intel | Disagree | This is in RAN3 scope, and could be driven by RAN1 input. |
| Apple | Disagree | We should wait a bit for more input from RAN1 and SA2.RAN node is definitely involved but it’s hard to say what is the additional processing at present. |
| Lenovo | Wait for RAN1 | RAN1’s input to ascertain which of the currently/new positioning methods are to be supported for network verified UE location. Furthermore, we disagree with the Rapporteur’s view that several positioning methods cannot be supported in combination to derive a UE’s position by the LMF. In fact, hybrid positioning has always been supported. |

Moderator summary

To clarify for participants who asked, some information (coordinate systems) or location algorithms are specific to NTN domain : implementing these specific computation in the CN should be further discuss.

Most companies recommend to wait for RAN1 to progress on the definition of solutions before taking a decision

## 3.1.4 Comparison criteria

RAN 1 is currently evaluating several positioning methods to support the UE location verification. RAN 2 should discuss some criteria corresponding to possible access layer impact.

Agreements and recommendations from TR 38.882 considers verified a reported UE location within 5-10 km.

Also, during the last online meeting RAN2#119-e, RAN2 started to discuss about the proposal 3 of the R2-XX from Thales :

*The network verification procedure should not impact significantly the latency impact of the multi-RTT computation on delay of the targeted regulated services (e.g. public warning system, lawful interception, emergency services, charging…) must be further studied.*

*- QC/Lenovo are fine*

*- Nokia wonders what “significantly” means*

*- Ericsson wonders why we need to list these services specifically. Ericsson thinks that verification can be done in the CN without the RAN knowing what happens*

In R2-2207326, Nokia and submitted the following proposal : “The extra latency introduced by the UE position verification should be kept as short as possible and should be below 1 s. More accurate value is FFS.”

NOTE that depending on the satellite orbit, the LEO satellite visibility duration is in the order of 5 to 20 minutes. We could consider that positioning methods with one satellite could take more than few seconds to perform the verification.

**Question 3.1.4-1 : Can companies provide their views on the bellow list of possible comparison criteria to assess candidate solutions to support the verification of UE location ?**

* **Latency ( response time )**
* **A metric that characterize the consistency of GNSS position with network based assessment.**
* **Signalling impact**
* **..**

|  |  |
| --- | --- |
| **Company** | **Comments/Suggestions** |
| Thales | Latency: a target maximum duration should be definedMetric: it could be a 2D position difference or a dilution of precision (DOP) term between the GNSS position and the calculated UE positions.Signalling impact: MAC or RRC signalling ? |
| Hispasat | Latency: maximum to be defined, based on final services.Metric: Accuracy as minimum 2D position difference from actual (real) GNSS position.Signalling impact: also related with latency, number of final operations to be implemented in the calculation and elements involved. Also consider the least difference to existing implemented methods. |
| vivo | We think Accuracy is needed. Per RAN1 agreements, it is clear that they have already taken positioning accuracy as the metric for evaluation and candidate solution comparison. As to latency, we first don’t think a service-associated latency needs to be considered. Also, this aspect on latency is also under consideration in RAN1 evaluation. We need to first wait for RAN1 conclusions on whether such latency aspect really matters and needs for intentional consideration, before taking any RAN2 conclusion.Generally speaking, except for accuracy, we currently don’t think other metrics really need to be further considered for candidate comparison. |
| CATT | We support these criteria in principle.Latency: In case of single satellite scenario, the possible measurement time, which contains serval measurement time points, is the mainly influence factor. The latency is impact by the evaluation from RAN1.Metric: In Rel-18, 2D positioning is enough for the target use case, for example, country discrimination.Signalling impact: We suggest changing this bullet as “Specification impact”. |
| Xiaomi | We think the metric and signalling impact should be considered. Whether the latency is considered should be determined by the SA2 since the use cases to verify UE location are from SA2.  |
| Docomo | We support these criteria.Small comment on metric: It is slightly incorrect to include "GNSS location" in the criterion, because this work assumes the GNSS location can be tampered with. Thus "A metric that characterize the consistency of the network based assessment with the actual UE location" is fine. |
| ZTE | Agree with latency which is under assessment in RAN1. As for signalling impact, we tend to share similar view as CATT it refers to specs impact which will definitely be considered when it comes to comparing among candidates. The metric is not clear to us, in our understanding the metric only matters when it comes to assessing the accuracy, than shall we add accuracy as comparison criteria instead? |
| Huawei, HiSilicon | Latency should be considered as already recommended in the TR: *“The solution should not impact significantly the latency of the targeted services nor infringe privacy requirements that apply to the UE location.*”Accuracy should also be considered as agreed by RAN: “For evaluating positioning performance in NTN, the following metrics apply: Horizontal accuracy”.Specs effort can also be considered. |
| Nokia | Latency: a target maximum value should be agreed and it should be a rather short value to minimize impact.Metric: the 2D distance between reported position and network determined position. Middle points can be considered in case of the network verification finding an area instead of a single point. |
| Samsung  | Similar view to Xiaomi, latency issue of UE location verification should be discussed in SA2. |
| Qualcomm | Latency should be the target performance mainly for RAN1 to design the solution. RAN2 should be able to help specifying it.Accuracy: We are ok to leave this to network how to meet the accuracy of 5-10km.Signaling: There will be signaling impact but can be discussed later. |
| Ericsson | We think the latency of the verification can be handled, see answer to next question.We agree with vivo that the accuracy of the NW verified location is the metric to evaluate a solution. Signalling impact or specification impact may be used to select a method if accuracy of the methods is equivalent. |
| Apple | In generally we think latency should be considered but input from SA1/SA2 is needed.Accuracy is pending to RAN1.Signaling impact can be evaluated when the candidate solutions are clearer.  |
| Lenovo | On Latency: We think it as an important parameter to consider, as mentioned by companies. Especially, this needs to be considered for the verification procedure.Metric: Accuracy metrics, already defined in TR 38.882, may be considered for the verification accuracy.Signalling impact: This can be studied later based on the supported solution(s). |

Moderator summary

Most companies agree to use the following criteria to compare the different candidate verification solutions

* Accuracy
* Latency (response time)
* A metric that characterize the consistency of the network based assessment with the actual UE location.
* Specification impact

Hence the moderator suggests the following

**Proposal: RAN2 will use the following comparison criteria to evaluate at RAN2 level the candidate network verified UE location solutions :**

* **Accuracy**
* **Latency (response time)**
* **A metric that characterize the consistency of the network based assessment with the actual UE location.**
* **Specification impact**

**The ranking of these criteria will be determined depending on RAN 1 and SA2 conclusions.**

**Question 3.1.4-2: What would be an acceptable latency for the verification procedure ? Does it depend on the targeted services ?**

|  |  |
| --- | --- |
| **Company** | **Comments/Suggestions** |
| Thales | It could be interesting to have two options depending on the targeted services. * Opt1: for targeted regulated services (e.g. public warning system, lawful interception, emergency services, charging…) with more flexible verification to ensure low latency verification.
* Opt2: for other services with a verification that could be carried out during the use of the service
 |
| Hispasat | Latency is an important method, but final selection should be based on the method with the least latency that can comply with the required accuracy. Agree that latency tolerance may vary from methods, but only one procedure should be chosen (with a concrete latency measure). |
| vivo | See comments earlier in Q3.1.4-1.  |
| CATT | Firstly, we agree to separate the discussion on targeted services. We suggest involving SA2 to discuss whether the regulated services could be carried out before or during the UE location is verified. Secondly, the possible measurement time is the mainly influence factor. Considering the interval between these measurement time points will influence the positioning accuracy, which should wait for the evaluation from RAN1. |
| Xiaomi | We think the acceptable latency should be determined by SA2. |
| OPPO | Different services may have different requirement on latency, but in any case, we should aim at low latency positioning. |
| Docomo | The latency should be dependent on services, or common but the most strict among targeted services.Annex A in TR38.882 can be a good starting point, i.e. no regulatory requirement for LI, PWS, nor Charging, but for emergency calls, the delay should be comparable with a typical call set-up; less than a second. |
| ZTE | I understand the question is to ask whether enhancements are needed to reduce latency of UE location verification procedure to meet the latency requirement of different service not to ask RAN2 to discuss the delay requirement of services.. As discussed in out paper, to meet the required accuracy requirement the verification period could be very large thus some enhancements might be needed, but since RAN1 is still assessing this aspect, we can discuss further after receiving their confirmation. |
| Huawei, HiSilicon | Latency requirements may vary with different services. Coordination with SA2 is required for this.  |
| Nokia | It should not depend on the service.  |
| Samsung  | See our answer to **Question 3.1.3-1.** Considering that the verification of UE location information is performed in the CN, so any discussion/decision related to latency of verification should be up to SA2. |
| Qualcomm | Latency should be the target performance mainly for RAN1 to design the solution. In that sense, we are ok to have an absolute number such as 5s for target performance and evaluation purpose. |
| Ericsson | We think this recommendation in the TR:The solution should not impact significantly the latency of the targeted services nor infringe privacy requirements that apply to the UE location.Shall be interpreted as: the network shall let the UE go into CONNECTED mode assuming the UE reported location is correct. This is further supported by the TR recommendations for the R1/R2/R3 study:- Assume that the UE is attached to a network (so that its context has been set up in the network) for the purpose of positioningEventually, when network verified UE location is available and differs from UE reported location, then core can initiate a switch (change AMF, PLMN etc.). With this interpretation, only UEs that report an incorrect UE location will experience a possible extra delay in the service. If UEs connect and leave before NW can verify the location, the NW may delay the UE leaving or/and learn which UEs (IMSI/IMEI) that does this and block further access.Thus, latency of the NW verification can be handled by the NW.  |
| Apple | We feel the latency requirement should be determined by SA2 (probably SA1 as well).It’s also preferred to discuss the services separately as different services may demand location verification at different time points. |
| Lenovo | Also share CATT’s view. The latency targets should consider the end-to-end latency for the network verification procedure. The considered positioning method(s) to be used for verification should fall within the defined latency target. RAN1 (for physical layer signalling) and SA2 (for CN signalling) inputs may also be required to help define this latency target. |

Moderator summary

Most companies seems to agree that the latency requirement depends on the targeted services. Therefore, many comments suggest to address this question to SA2.

The moderator suggests to the following proposal :

**Proposal: Send a LS from RAN2 to SA2 asking about the required maximum latency ? And does it depend on the regulatory services.**

## 3.1.5 Validity period

NGSO or UE can move with considerable speed (LEO satellite, UE in a plane). In few minutes, measurements could change due to handover or a UE on the move.

Also, the redundant verification could lead to latency issues.

In R2-2207296, NEC Telecom MODUS Ltd. submitted the following proposal : *“After passing a verification following a network verified location, the location provided by the UE should only be trusted for a period of time.”*

In R2-2208546, ZTE Corporation and Sanechips wants to introduce flag on verified UE to reduce the frequency of verification procedure.

**Question 3.1.5-1: Can companies share their views on the period during which the UE location is considered reliable after the execution of the network verification procedure ?**

|  |  |
| --- | --- |
| **Company** | **Comments/Suggestions** |
| Thales | It should be configurable but we think that this question should be addressed to SA2. |
| Hispasat | Configurable in CN, and deployment driven. Depending on system architecture (e.g. beam size) and services included by the operator/regulator, lifetime may vary. |
| vivo | We think whether such a validity period is really needed should be first discussed, and this is related to whether the location verification mechanism should be periodically performed or one-shot/event triggered. So, we think it is currently too early to decide such details on what such validity period should be, before deciding whether it is really needed and seeing how the whole mechanism actually works. |
| CATT | No need to restrict a validity period.In case of location verification, the CN know when to do it, one time or periodically. RAN2 only need to do measurement and report after receiving the indication or request from CN. This question should be determined by SA2. |
| Xiaomi | It should be discussed by SA2. |
| OPPO | We think this should be up to CN and no need to discuss this in RAN2. |
| Docomo | We think it will be fine to simply ask SA2, or rather to raise the same question in SA2 (not via LS). |
| ZTE | The intention is to reduce the frequency of UE location verification procedure since the verification period might be very long. But as comment in 3.1.4-2, we don’t need to make decision until receiving more input from RAN1. |
| Huawei, HiSilicon | Can be left to NW implementation. If CN thinks the verification result is expired, it can initiate another verification. |
| Nokia | In principle it can be based on the time it would take the UE to move out of the 10 km accuracy requirement. Considering a speed of like 240 km/h, the time would be 2,5 min. |
| Samsung  | Similar view to other companies, this issue should be discussed in SA2.  |
| Qualcomm | We agree with Thales this can be in the scope of SA2. |
| Ericsson | Not a RAN nor RAN2 issue.  |
| Intel | It can be CN implementation, no RAN2 spec impact foreseen. |
| Apple | We think this question requires input from RAN1 at least. SA2 may also be involved on the need of this metric. |
| Lenovo | The RAT-dependent verified location should be considered valid for a period of time such that new RAT-dependent verified location procedures need not to be triggered continuously. Another option may be that the UE reported GNSS can be trusted upon initial successful UE location verification and may be further used, if needed, during validity period. These aspects may also be considered by SA2. |

Moderator summary

**Proposal: Send a LS from RAN2 to SA2 to ask if a period in which the UE location is considered reliable after the execution of the network verification procedure is needed.**

## 3.1.6 Reliability of UE reported Information

The TR 38.882 [1] recommends to consider solution based on positioning methods and existing 3GPP defined RAT dependent positioning methods shall be considered as baseline. Also, the document recommends that the verification should be performed independently from the location information reported by the UE (e.g. GNSS)

In R2-2207296 (NEC Telecom MODUS Ltd), R2-2207274 (Intel Corporation), R2-2207779 (Samsung R&D Institute UK), R2-2208328 (NTT DOCOMO INC), R2-2208546 (ZTE Corporation, Sanechips) express concern about the reliability of UE information reported.

The RAT positioning methods are listed in the TS 38.305 [2] in the table *4.3.1-1: Supported versions of UE positioning methods.* Some of these methods are UE-assisted.

During the last plenary meeting #96, it was mentioned orally that 3GPP defined functions shall be considered as trustworthy.

**Question 3.1.6-1: Can the UE reported information (e.g. TA) as part of 3GPP defined network or UE based functions be trusted if not derived exclusively from information provided by non 3GPP defined function (e.g GNSS) ?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| Thales | Agree |  |
| Hispasat | Agree |  |
| vivo | Disagree with comments | We don’t think this question makes much sense, as the answer could be different case by case, depending on what specific info is to be reported by the UE.In addition, we think whether the TA related POS method really needs to be supported for this verification purpose should depend on RAN1 evaluation results. If RAN1 concludes not (e.g. DL-TDOA is sufficient), it makes no sense to discuss this question and any forms of TA related POS methods any longer. Also, even if RAN1 concludes the TA related POS method is needed, we would like to prioritize those existing positioning methods as much as possible, instead of introducing new mechanism (e.g. method based on UE TA reporting as discussed later in subclause 3.1.7), unless necessity is fully justified.  |
| CATT | Agree |  |
| Xiaomi | Agree |  |
| OPPO | Not decided by RAN2 | Whether trusted or not trusted should be decided by SA3. This is not the domain of RAN2. |
| Docomo | Disagree | It is safer if RAN2 do not preclude to separately ask SA3 whether a certain reporting can be trusted. As for TAR, we are wondering if it is easy to report a wrong value of TA if a malicious UE can tamper with its GNSS information, because the TA value is derived just from the ephemeris and the GNSS. |
| ZTE | Agree |  |
| Huawei, HiSilicon | Disagree | The purpose of UE location verification is to verify the location/TA reported by UE. So obviously this cannot be fully trusted if it is obtained using GNSS information. Meanwhile, it is observed in the TR:” 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)” But generally, RAN2 cannot make the decision of what information reported by UE can be trusted and what cannot without SA3’s confirmation. |
| Nokia | Agree | Yes, these can be trusted |
| Samsung  | Disagree  | Similar view to OPPO. Whether certain UE reported information is trustable should be discussed/decided in SA3. |
| Qualcomm | Agree | Something that cannot be tampered with should be trusted such as TA being used by the UE PHY layer. |
| Ericsson | Disagree | Even though the UE reports an incorrect UE location, it must still use the true UE location for calculating the TA and doppler pre-compensation, otherwise the UE can likely not communicate with the NTN (or transmissions arriving at the gNB will be well outside the cyclic prefix and non-aligned with the intended frequency band). Thus, a fake reported UE location means the 3GPP chipset is already handling two UE locations, and it would be super simple for the UE to report a TA corresponding to the reported fake UE position. The TR observation:The RAN can also request radio measurements (intra-RAT neighbours, inter-RAT neighbours, WLAN, etc.) from the UE; these may be used to drive NNSF and to learn from the environment.Some further observations:a) 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); we interpret as RRM measurements may be trusted, so for example RSRP/RSRQ for multiple cells from the same satellite may be assumed to be correct.  |
| Intel | Not decided by RAN2 | TA is also derived based on GNSS, so SA3 needs to discuss whether it can be trusted. |
| Apple | See comments | For UE reporting, in general the information derived based on 3GPP RAT measurement should be trustworthy. But for TA, since UE calculates TA based on ephemeris data in NTN, it’s hard to say it still can be trusted.  |
| Lenovo | Disagree | Share Intel’s view. We should carefully consider the information provided by UE GNSS for positioning verification purposes.  |

Moderator summary

**Proposal: Send a LS from RAN2 to SA3 & SA3-LI to ask whether UE reported information (e.g. Timing Advance) which are computed by the UE using GNSS position can be used by the network for the verification of the UE reported location ?**

**Proposal: the UE reported information exclusively provided by 3GPP defined functions can be used by the network for the verification of the UE reported location.**

## 3.1.7 Timing Advance Reporting

UE have the ability adjust its uplink transmission by reporting a Timing Advance Report (TAR) contained in the MAC PDU (MAC Control Element).

The length of the field is 14 bits (see TS 38.321, clause 6.1.3.56).

Also, the TAR is triggered if any of the following events occur (see TS 38.321, clause 5.4.8):

-     upon indication from upper layers to trigger a Timing Advance report;

-     upon configuration or reconfiguration of *offsetThresholdTA* by upper layers, if the UE has not previously reported Timing Advance value to current Serving Cell;

-     if the variation between current information about Timing Advance and the last reported information about Timing Advance is equal to or larger than *offsetThresholdTA*, if configured.

The Timing Advance Report is a candidate measurement to be used for the Multi-RTT positioning method as MediaTek Inc. mentions it in R2-2207302 *“Proposal 1: Multi-RTT method with UE using its location and the satellite ephemeris to calculate and report the UE-specific TA to the network at different times over a verification period of a few seconds is the baseline for network-based UE location verification.”*

In R2-2208775, Thales asks that the precision of the Timing Advance (TA) reported needs to be further investigated. RAN2 should send an LS to RAN1 about the performance of the technique in a single satellite context.

**Question 3.1.7-1: Should RAN2 send a LS to RAN 1 asking to evaluate the granularity required for TA to be used in the multi-RTT positioning method ?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| Thales | Agree |  |
| Hispasat | Agree |  |
| vivo | Disagree | Our understanding is that RAN1 has already set evaluation assumption with candidate solutions decided, and will discuss simulation results in the next meeting. So, it is fully up to RAN1 on the candidate positioning methods, and there is no need to send LS at this stage. Also, we fail to understand the feasibility to use the TA reporting information: now that UE GNSS is regarded as not trusted with the verification procedure initiated, how can the TA value in the TAR, which is just calculated based on UE’s GNSS info, be trusted and used for verification purpose? |
| CATT | Maybe | But the positioning method seems not multi-RTT anymore. The multi-RTT is calculated by the Rx and Tx time of SRS and PRS. Maybe a new RAT dependent positioning method, e.g. Multi-TA, can be introduced. |
| Xiaomi | Disagree | We think RAN1 can discuss it directly since the positioning method is in RAN1 scope. |
| OPPO | See comments | We should first ask SA3 whether TA reporting is trustable before asking RAN1 to work on the detailed design. |
| Docomo | Disagree | We are not sure what to discuss first in RAN2. Proponents can raise the multi-TA method directly on the RAN1 table. |
| ZTE | Not strong view. | For our information RAN1 is already consider TA as one of the candidate solution for evaluation which includes required granularity for reporting. An LS might not be necessary at this stage, but we are fine with the LS if there is a majority support. Since TA will be used for scheduling adjustment, the cost of faking TA continuously might be too large since UE’s interaction with NW might be jeopardized. Therefore, multiple TA report can be trusted. |
| Huawei, HiSilicon | Disagree | We can wait for RAN1’s progress for now as the positioning method is not decided yet. |
| Nokia | Agree |  |
| Samsung  | Disagree | Similar view to other companies, the positioning method and whether TAR is going to be used are in RAN1 scope. |
| Qualcomm | Disagree | We also think there is no need for LS now. If TA report based mechanism is used, then we may need to define new granularity. |
| Ericsson | Disagree | Reported TA is useless for verifying the UE location, see previous question. If RAN1 decides on a solution that requires RAN2 protocol changes, they will liaison RAN2. |
| Intel | No strong view | We need the answer to whether TA report can be trusted first. |
| Apple | See comments | The LS is not needed for now.  |
| Lenovo | Disagree | Wait for RAN1’s conclusion. Multi-RTT is based on time difference measurements between the PRS and SRS. |

Moderator summary

The previous question 3.6.1-1 has to be considered first. The evaluation of a positioning method relying on TA is in the scope of the RAN1.

Most companies disagree and hence the moderator suggests to close the discussion.

**Question 3.1.7-2: Companies are invited to provide their views on the need for signalling enhancement to report high accuracy TA calculated by the UE (e.g. through an RRC message) ?**

|  |  |
| --- | --- |
| **Company** | **Comments/Suggestions** |
| Thales | Ok but we should wait for RAN1 recommendations. |
| Hispasat | Ok, but when consensus in RAN1 about using this method. |
| vivo | Too early to decide. First await the down-selection among positioning methods to be done by RAN1. |
| CATT | Wait for the evaluation from RAN1. |
| Xiaomi | Wait for the RAN1 conclusion on the positioning methods. |
| OPPO | Before SA3 confirms TA reporting is trustable. |
| Docomo | Ok if RAN1 requests. |
| ZTE | Wait for RAN1 |
| Huawei, HiSilicon | Wait for RAN1’s progress. |
| Nokia | Too early to decide |
| Samsung  | Similar view to above. RAN2 should wait for RAN1 recommendations. |
| Ericsson | Wait for RAN1. |
| Intel | Too early to decide |
| Apple | Fine to wait. |
| Lenovo | RAN1 needs to decide if the TA method is a viable approach for NW UE verification. |

Moderator summary

The question 3.1.6-1 has to be considered first. The evaluation of a positioning method relying on TA is in the scope of the RAN1. The accuracy needed would be provided by RAN1 if the method is selected.

Most companies think it is too early to decide and hence the moderator suggests to close the discussion for the time being.

## 3.1.8 Terrestrial Network assisted methods

Deutsche Telekom , Huawei , HiSilicon suggested in R2-2208022 to take in consideration how NTN network can instruct the UE to report TN PLMN identities for UE location verification :

*“As it is assumed that the UE is connected to the NTN when it has reported its GNSS based location, the NTN can instruct the UE via RRC signalling to perform measurements, identification and reporting of TN neighbouring cells”*

*“For instance, if a UE reported its location to be in Germany (based on GNSS location information), it will not be able to read and report a Greek PLMN ID (MCC/MNC) from a particular TN frequency; thus, possible cases of malicious UEs can be identified and prevented properly”*

**Question 3.1.8-1: Could RAN2 evaluate which information related to Terrestrial Network could be used for UE location verification (e.g. PLMN identities, MCC, MNC) ?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| Thales | - | The main priority remains to have a generic NTN solution. The use case for such proposal should be clarified. |
| Hispasat | Disagree | If TN network is available, no NTN location verification may be needed. Solutions in this study should focus on the worst scenario possible, only NTN coverage and no terrestrial assistance. |
| vivo | - | We may first wait for RAN1 evaluation on whether related existing POS methods in NG-RAN are already sufficient to accomplish this verification purpose. If so, we may not need to consider extra mechanism. |
| CATT | Tend to disagree | What if there is no TN in this region? Additionally, this may have extra requirements on UE capability. |
| Xiaomi | Disagree | A solution for all scenarios is preferred. |
| OPPO | Disagree | This is not a generic solution and should be deprioritized. |
| Docomo | Disagree | We should focus on general solutions, i.e. these applicable even where no TN coverage can be found. |
| ZTE | Support to further study | We see some benefits of this approach especially for countries discrimination use case. Considering the TN cell size is around 5-10km therefore to allow report of TN cells can already fulfill the requirement and the procedure can be discussed in RAN2 without waiting for RAN1 input. Since it has no dependency on positioning method it can be used for equipment without positioning capabilities. Therefore we support to further discussed this approach. |
| Huawei, HiSilicon | Agree | While LCS procedure should be the baseline and which positioning method to use should wait for RAN1, other solutions can also be considered if helpful. |
| Nokia | Agree | Besides these information, other information like angle of arrival, neighbour measurement levels etc may also be considered. |
| Samsung  | Disagree |  |
| Qualcomm | Disagree | There is no guarantee of TN network availability. |
| Ericsson | Disagree | Agree with OPPO. |
| Intel | Agree | RAN2 can discuss which information is useful. |
| Apple | Disagree | Indeed this is not a generic solution. UE may not be able to find a EPLMN TN cell nearby. |
| Lenovo | Disagree | In case of a mixed multi-connectivity scenario involving TN NG-RAN and NTN NG-RAN, the verification procedure does not need to involve NTN NG-RAN and is based on cell-ID of TN NG-RAN.  |

Moderator summary

Most of companies disagree to use information related to terrestrial network on the basis of :

* That there is no guarantee of terrestrial network availability
* That it is not a generic solution

## 3.1.9 Other

**Question 3.1.9-1: Do companies have other proposals to be discuss as part of his e-mail discussions**

|  |  |
| --- | --- |
| **Company** | **Comments/Suggestions** |
| CATT | Before evaluate and determine the positioning methods, we should limit and clarify the positioning scenarios, e.g. NGSO, GSO or HAPS. For their different moving characteristic may have influence on the selection of positioning method, procedure and so on.  |
| Samsung  | We would like to remind everyone of RAN2 LS to SA2 (LS in R2-2208779), requesting SA2 feedback on UE location verification, as some questions in this email discussion maybe pending on SA2 feedback/reply LS. “*RAN2 is considering the re-use of the LCS framework of the LMF for the network verification of UE reported location information in NTN.**RAN2 would like to inform SA2 about this agreement and ask for any related feedback.*” |
| Lenovo | We need to coordinate with SA2, RAN3 on the impact of different multi-connectivity NTN architectures on positioning procedures and verification procedures, e.g., use of multi-satellites with multiple gateways and different AMFs/LMFs since satellites can span large areas with multiple PLMNs. |

Moderator summary

CATT and Lenovo questions will be discussed in the round 2 section of this post-email discussion.

Samsung reminds everyone of RAN2 LS to SA2 (LS in R2-2208779), requesting SA2 feedback on UE location verification, as some questions in this email discussion maybe pending on SA2 feedback/reply LS.

# 4. Discussion (2nd round)

## 4.1 Verification procedure

**Proposal 1: The network shall be able to compute a possible UE location with uncertainty area independently from the location information reported by UE.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| OPPO | Agree |  |
| Docomo | Agree | Align to TR recommendation. |

**Proposal 2: The network (5GC) shall implement a method to verify the consistency (within 10 km) between the actual reported UE location with the UE location/its uncertainty area computed by the network**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| OPPO | Agree |  |
| Docomo | Agree, but | We’d like to add “if the computation in the network is based on LCS”. We think verification in RAN should not be precluded considering that RAN-based solution is not precluded in the last meeting. |

## 4.1 Triggering

**Proposal 3: It is assumed that the verification procedure can be triggered by the CN any time after initial registration**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| OPPO | Agree |  |
| Docomo | Agree, but | We’d like to add “if the location calculated by LCS is used for the verification”. We think RAN-initiated verification should not be precluded considering that RAN-based solution is not precluded in the last meeting. |

## 4.2 Comparison criteria

**Proposal 4: RAN2 will use the following comparison criteria to evaluate at RAN2 level the candidate network verified UE location solutions :**

* **Accuracy**
* **Latency (response time)**
* **A metric that characterize the consistency of the network based assessment with the actual UE location.**
* **Specification impact**

**The ranking of these criteria will be determined depending on RAN 1 and SA2 conclusions.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| OPPO |  | Not sure whether RAN2 can evaluate accuracy/consistency which seems to be RAN1’s area. |
| Docomo | Partially | - In our understanding, “Accuracy” and “A metric that ...” is the same criterion.- (Apologies not commented on 1st round) We think that the accuracy is a requirement rather than a criterion. In other words, solutions have to achieve accuracy requirement (< 5-10 km), but we are not motivated to select the solution which is “more accurate” among good solutions (i.e. solutions which already achieve the accuracy requirement).- Agree that the latency and the spec impact are criteria for comparison. |

## 4.3 SA2 LS about latency and validity period

**Proposal 5: Send a LS from RAN2 to SA2 asking :**

* **What is the maximum latency for the verification procedure to be performed ?**
* **Does this maximum latency requirement depend on the type of regulatory services (e.g. emergency call, lawful intercept, etc..).**
* **What is the period during which a verified UE location is considered reliable ?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| OPPO | No strong view | Not sure what kind of impact to RAN2’s work is expected if SA2 provides a latency requirement. |
| Docomo | No strong view | It may be RAN1 who should ask SA2 about the latency rather than RAN2, but we follow the majority view. |

## 4.4 Reliability of UE reported Information

**Proposal 6: Send a LS from RAN2 to SA3 & SA3-LI to ask whether UE reported information (e.g. Timing Advance) which are computed by the UE using GNSS position can be used by the network for the verification of the UE reported location ?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| OPPO | Disagree | TA reporting is being discussed in RAN1 as one candidate method and there was already discussion whether RAN1 should ask SA3 on the feasibility. For this specific positioning method, we should rely on RAN1 to conclude whether it is feasible or not, i.e. the LS to SA3 should be triggered by RAN1. |

**Proposal 7: the UE reported information exclusively provided by 3GPP defined functions can be used by the network for the verification of the UE reported location.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| OPPO |  | OK if the intention is to exclude any information related to TA (if TA is considered as not trustable by SA3) /GNSS. |

## 4.5 Scenarios

*“Before evaluate and determine the positioning methods, we should limit and clarify the positioning scenarios, e.g. NGSO, GSO or HAPS. For their different moving characteristic may have influence on the selection of positioning method, procedure and so on.” – CATT*

**Question: Please share your views and expectations regarding the scenarios (GSO, NGSO, HAPS) for the study of network verified UE location solutions at RAN2 level.**

 **Some parameters that could be taken into consideration :**

* **type of orbit (GSO, NGSO, HAPS)**
* **beam characteristic (Earth moving/fixed)**

|  |  |
| --- | --- |
| **Company** | **Comments/Suggestions** |
| OPPO | We think NGSO can be prioritized. Both earth moving and earth fixed can be covered. |
| Docomo | Type of orbit is worth considering because multi-RTT solutions cannot be applied for GSO. |

*“We need to coordinate with SA2, RAN3 on the impact of different multi-connectivity NTN architectures on positioning procedures and verification procedures, e.g., use of multi-satellites with multiple gateways and different AMFs/LMFs since satellites can span large areas with multiple PLMNs.” – LENOVO*

**Proposal 8: Send a LS from RAN2 to SA2 and RAN3 to start evaluating the impact of different *multi-connectivity NTN architectures on positioning procedures and verification procedures.***

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Comments/Suggestions** |
| Thales | Disagree | NTN multi-connectivity support is not part of the release 17 & 18. |
| OPPO | Disagree | Same view as Thales. |
| Docomo | Disagree | Share view of Thales. |

# 5. References

1. 3GPP TR 38.882 “Study on requirements and use cases for network verified UE location for Non-Terrestrial-Networks (NTN) in NR”, v18.0.0
2. 3GPP TS 38.305 “NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN”, v17.1.0
3. 3GPP Contribution "Discussion on network verified UE location", R2-2207074, OPPO
4. 3GPP Contribution "Network verified UE location aspects", R2-2208775, THALES
5. 3GPP Contribution "Discussion on network verified UE location", R2-2207274, Intel Corporation
6. 3GPP Contribution "Assumptions on Network verified location", R2-2207296, NEC Telecom MODUS Ltd.
7. 3GPP Contribution "On Network Verified UE Location in NR-NTN", R2-2207302, MediaTek Inc.
8. 3GPP Contribution "Considerations on NW-verified UE location", R2-2207326, Nokia, Nokia Shanghai Bell
9. 3GPP Contribution "Consideration on NTN Network Verified UE Location", R2-2207444, Apple
10. 3GPP Contribution "Discussion on the network verfied UE location", R2-2207482, Huawei, HiSilicon
11. 3GPP Contribution "Discussion on NW verification of UE location in Rel-18 NR NTN", R2-2207634, vivo
12. 3GPP Contribution "Discussion of Network verified UE location in NTN", R2-2207645, China Telecom
13. 3GPP Contribution "Discussion on UE location verify procedure", R2-2207675, Spreadtrum Communications
14. 3GPP Contribution "Network Verified UE Location", R2-2207779, Samsung R&D Institute UK
15. 3GPP Contribution "On NTN NW verified UE location aspects", R2-2207866, Lenovo
16. 3GPP Contribution "Discussion on network verified UE location", R2-2207915, Xiaomi
17. 3GPP Contribution "UE location verification in NTN", R2-2208022, Deutsche Telekom, Huawei, HiSilicon
18. 3GPP Contribution "Discussion on Network Verified UE Location", R2-2208328, NTT DOCOMO INC.
19. 3GPP Contribution "Discussion on UE Location Verification", R2-2208376, CATT
20. 3GPP Contribution "Consideration on UE Location Verification via Network", R2-2208444, CMCC
21. 3GPP Contribution "Consideration on NW verified UE location", R2-2208546, ZTE Corporation, Sanechips
22. 3GPP Contribution "R18 NR NTN Network verified UE location", R2-2208674, Ericsson

# 6. Annex

## 6.1 Parameters for evaluation of RAT

**3GPP TSG RAN meeting #97-e**

**e-meeting, Sept 12 - 16th, 2022**

**RP-222019** *revised RP-221746*

**Status report for WI NR NTN (Non-Terrestrial Networks) enhancements**

**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 |

# 7. Contact information

|  |  |
| --- | --- |
| Company | Delegate contact |
| COMPANY\_NAME | NAME (email@address.com) |
| Thales | quentin.baradat@thalesaleniaspace.com |
| Hispasat | jgarcia@hispasat.es  |
| vivo | xiao.xiao@vivo.com |
| Xiaomi | Xiaolong Li@xiaomi.com |
| OPPO | lihaitao@oppo.com |
| NTT Docomo | riki.ookawa.rp@nttdocomo.com |
| Huawei, HiSilicon | xubin10@huawei.com |
| Samsung  | c.khirallah@samsung.com  |
| Ericsson | robert.s.karlsson AT ericsson.com |
| Intel | Tangxun (xun.tang@intel.com) |
| Apple | Yuqin Chen (yuqin\_chen@apple.com) |