3GPP TSG-RAN WG2 Meeting #114 Electronic R2-210xxxx

Online Meeting, May 19 – 27 2021

**Agenda item: 8.11.6**

**Source: CATT**

**Title: [AT114-e][108][NTN] UE location aspects (CATT)**

**WID/SID: NR\_NTN\_solutions-Core**

**Document for: Discussion and Agreement**

# 1 Introduction

This document is to kick off the following email discussion:

* [AT114-e][108][NTN] UE location aspects (CATT)

Initial scope: Based on the received LSs, discuss:

1. discuss the need and possible mechanism to ensure (for both the earth-fixed and earth-moving cell cases) that the CGI constructed by NG-RAN corresponds to a fixed geographical area with a size comparable with a cell for TN (e.g. for registration to the correct core network in case of NTN cells crossing country borders)
2. whether RAN2 needs to do anything (and in case what) to ensure that that final UE location information at the core network is trustable

Initial intended outcome: Summary of the offline discussion with e.g.:

* + - List of proposals for agreement (if any)
    - List of proposals that require online discussions
    - List of proposals that should not be pursued (if any)

Initial deadline (for companies' feedback): Friday 2021-05-21 10:00 UTC

Initial deadline (for rapporteur's summary in R2-2106527): Friday 2021-05-21 16:00 UTC

Proposals marked "for agreement" in R2-2106527 not challenged until Monday 2021-05-24 10:00 UTC will be declared as agreed via email by the session chair.

For the rest the discussion will continue online in the Monday CB session.

This email discussion continue to discuss the need and possible mechanism to ensure (for both the earth-fixed and earth-moving cell cases) that the CGI constructed by NG-RAN corresponds to a fixed geographical area with a size comparable with a cell for TN (e.g. for registration to the correct core network in case of NTN cells crossing country borders) both in Idle state and Connected state based on the reply LSs.

Also we start to discuss whether RAN2 needs to do anything (and in case what) to ensure that final UE location information at the core network is trustable which was not discussed online yet.

# 2 Contact Information

Respondents to the email discussion are kindly asked to fill in the following table.

|  |  |
| --- | --- |
| Company | Contact: Name (E-mail) |
| Samsung | Nishith.t@samsung.com |
| Sony | Vivek.sharma@sony.com |
| Apple | svangala@apple.com |
| MediaTek | Abhishek.Roy@mediatek.com |
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# 3 Discussion

## 3.1 The need to ensure CGI constructed by NG-RAN comparable with a cell for TN

### In CONNECTED State:

In the reply LS[1] , SA2 mentioned the CGI requirement:

SA2 notes that the accuracy of a CGI may either need to align with the accuracy of a CGI for TN in certain regions such as where an emergency services call needs to be routed to a specific PSAP associated with the current location of a UE, (i.e. the CGI constructed by the NTN based NG-RAN should correspond to a fixed geographical area whose size shall be comparable with a cell for TN), or, the core network may initiate UE location procedure after registration in some cases, e.g. emergency call procedures, which may be used when an N2 provided ULI is considered insufficient, as is currently described e.g. in the Registration procedure in TS 23.502.

SA2 further notes that it is necessary to provide an accurate CGI to 5GC after a UE has entered CONNECTED state.

For regulatory reasons, either network determined or network verified UE location is needed, as described in previous LS from SA3-LI (S3i200056).

There are two options on the need or not to ensure (for both the earth-fixed and earth-moving cell cases) that the CGI constructed by NG-RAN corresponds to a fixed geographical area with a size comparable with a cell for TN in Connected state after registration:

* **Option 1**: No need to ensure (for both the earth-fixed and earth-moving cell cases) that the CGI constructed by NG-RAN corresponds to a fixed geographical area with a size comparable with a cell for TN in Connected state after registration.
* **Option 2**: Need to ensure (for both the earth-fixed and earth-moving cell cases) that the CGI constructed by NG-RAN corresponds to a fixed geographical area with a size comparable with a cell for TN in Connected state after registration.

During the online discussion, some companies believe that as the SA2 LS says, we could use existing procedures to determine and verify the UE location after registration. UE should not be required to map its location to e.g. a zone ID or anything like that. So RAN2 might not need to do anything.

But some companies believe that we need the same granularity as in TN and the UE location should be trustable.

Companies will continue the discussion of requirement at first and figure out if there is such need in CONNECTED state.

**Question 1-1: Which option do company preferred to support?** **Please specify the reasons or comments if any.**

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| Company | Option 1/ Option 2 | Comments |
| Samsung | Option 2 | We need to consider this issue in the overall NTN context. First of all, either the UE or the gNB can determine the identity of a hypothetical virtual cell or logical cell on the ground such that the size of such cell is comparable to a TN cell.  If RAN2 provides a mechanism that provides the virtual cell ID (VCID) associated with the UE’s current location, the 5GC does not need to invoke the UE location procedure and waste additional resources in the radio network and the core network for all UEs that would be performing initial registration or registration update. Furthermore, the gNB needs to select or use an AMF based on the UE’s current location. So, the gNB must know the TAC where the UE is currently located. Without VCID and associated determination of the Earth-fixed TAC, the gNB cannot choose the correct AMF. We observe that the UE or the gNB would not know the VCID/TAC when the gNB’s beam for an NTN cell illuminates multiple Earth-fixed TACs.  The determination of the VCID and the exact TAC in the NG-RAN would enable the gNB to always choose the correct core network (even when the UE crosses from one TAC to another TAC within the same NTN cell) of the correct country and the correct service provider within a given country. This will also avoid the costly location procedures. Without an explicit determination of the VCID and the TAC ID, the network would not even know WHEN and HOW OFTEN to invoke the location procedure, leading to a Tsunami of AS and NAS signaling. |
| Sony | Option 2 | We think the RAN should provide same granularity as cell size, even finer granularity e.g. pre-defined area ID within a cell. This may be done by RAN node itself and with UE and/or with Location server assistance. |
| Apple | Option 2 | While we find it very interesting that the Apple paper [R2-2105117](file:///C:\Data\3GPP\Extracts\._R2-2105117%20Satellite%20Cell%20ID%20Mapping%20to%20Earth%20Fixed%20Locations.docx), on the same topic is not considered for this offline, we also understand that it has been submitted in an entirely different section like the Huawei paper (R2-2105610). We request RAN2 to also have a look at it as part of this discussion in terms of the mapping itself.  In general, with the ideas of VCID (or zone ID/logical cell ID/Earth fixed Cell ID) we can benefit the overall NTN system in the following procedures. As mentioned in [10], a group of TN cells themselves can be used as earth fixed location cell IDs to make mapping easier and help get granularity in NTN as in TN. If RAN2 approves these solutions group, the following benefits can be achieved.  - There will then be no need for the core network to invoke unnecessary UE location procedures on potentially 100s of UEs for registration updates. If a more deterministic solution in terms of load management is needed, on when and how the location invocation procedures have to be triggered, additional information exchange between RAN and core is anyway needed. With the earth fixed cell ID approach, the AMF can continue to operate in a similar way as in existing terrestrial nodes despite the large satellite cell sizes with the gNB doing the translation.  - The trust and granularity of UE location is determined by the earth fixed cell ID. If granularity better than this value is needed in future, these solutions are extensible to fit those needs.  - TN like granularity can still be achieved in a network determinable and verifiable manner for emergency services.  - Core network selection by gNB is driven by the smaller earth fixed cell IDs thus avoiding ambiguities at international boundary situations  - UE reselection procedures apply only if it moves out of the geographically fixed earth locations and do not need to be invoked in case of a satellite change. |
| MediaTek | Option 1 | For Rel-17, we suggest only GNSS reporting for accurate position information. We can introduce network verifiable location in Rel-18 when we have more time available. |
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**Summary:**

### In initial access (security not activity):

There is such situation, e.g. for registration to the correct core network in case of NTN cells crossing country borders. Network needs to ensure (for both the earth-fixed and earth-moving cell cases) that the CGI constructed by NG-RAN corresponds to a fixed geographical area with a size comparable with a cell for TN in initial access (security not activity).

There are two options on the need in initial access (security not activity):

* **Option 1:** No need to ensure (for both the earth-fixed and earth-moving cell cases) that the CGI constructed by NG-RAN corresponds to a fixed geographical area with a size comparable with a cell for TN in initial access (security not activity).
* **Option 2:** Need to ensure (for both the earth-fixed and earth-moving cell cases) that the CGI constructed by NG-RAN corresponds to a fixed geographical area with a size comparable with a cell for TN in initial access (security not activity).

Some companies think it is not mandatory to ensure the accurate CGI in initial access (security not activity) according to the CR [5] of TS 23.502 clarifying what AMF should take actions during the initial registration

##### 4.2.2.2.2 General Registration

For NR satellite access, if the AMF can determine based on the Selected PLMN ID and ULI (including Cell ID) received from the gNB that the UE is attempting to register to a PLMN that is not allowed to operate at the present UE location, then the AMF should reject the Registration Request indicating a suitable Cause value and, if known in AMF, the country of the UE location. Otherwise, e.g. if the AMF is not aware of the UE location with sufficient accuracy to make a final decision, the AMF proceeds with the Registration procedure and may initiate UE location procedure as specified in TS 23.273 [51], clause 6.10.1 and be prepared to deregister the UE if the information received from LMF proves that the UE is registered to a PLMN that is not allowed to operate in the UE location.

NOTE 4: The location information cannot be guaranteed to be sufficiently accurate for the AMF to determine in all cases the country where UE is located.

NOTE 5: Some countries use multiple MCCs and some MCCs, such as 901, can be allowed in multiple countries and therefore the UE can register in a PLMN with MCC different from the one returned to the UE.

Upon receiving a Registration Reject with the country in which the UE is located, the UE shall attempt to register to a PLMN that is allowed to operate at the UE location as specified in TS 23.122 [22].

However some companies believe that there is a need to ensure (for both the earth-fixed and earth-moving cell cases) that the CGI constructed by NG-RAN corresponds to a fixed geographical area with a size comparable with a cell for TN in initial access (security not activity).

Companies will continue to discuss if there is a need to ensure (for both the earth-fixed and earth-moving cell cases) that the CGI constructed by NG-RAN corresponds to a fixed geographical area with a size comparable with a cell for TN in initial access (security not activity).

**Question 1-2: Which option do company preferred to support? Please specify the reasons or comments if any.**

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| Company | Option 1/ Option 2 | Comments |
| Samsung | Option 2 | There is absolutely no way for the AMF to even know whether to accept or reject the registration based on the CGI because the gNB’s beam in an NTN cell may be covering multiple TACs if the CGI corresponds to the NTN cell and if no information on the VCID and/or correct TAC of the UE is provided by the gNB to the AMF.  Before the security is activated, the UE can report a “transformed position” instead of the actual position. The knowledge of the relationship between the transformed position and the actual position can be used by the network (e.g., gNB and/or the AMF) (provisioned by OAM) to determine the actual UE position. |
| Sony | Option 2 | Relying on core network signalling is feasible as already agreed by SA2 but not optimal in terms of signalling overhead. |
| Apple | Option 2 | The simplest way for the above AMF registration procedure in 4.2.2.2.2 can achieve TN like granularity in NTN is by using VCID/Zone ID etc.. Consider the situation where the satellite is at the border and covering a large size cell sizes into the interior of both the neighboring countries. Is it preferable for the core network to initiate location information of UEs in the neighboring country only to reject them later or use the gNB as an assistance to not even invoke the procedure and save unnecessary signaling ? |
| MediaTek | Option 1 | For Rel-17, we suggest only GNSS reporting for accurate position information. We can introduce network verifiable location in Rel-18 when we have more time available. |
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**Summary:**

## 3.2 Possible mechanism to ensure the need

The following possible mechanism options can be considered to ensure (for both the earth-fixed and earth-moving cell cases) that the CGI constructed by NG-RAN corresponds to a fixed geographical area with a size comparable with a cell for TN (e.g. for registration to the correct core network in case of NTN cells crossing country borders):

* **Option 1: gNB report Earth-Fixed Virtual Cells[14]:**

gNB determines the ID of the Earth-fixed cell (e.g., a “virtual cell”) based on the position and possibly other quantities (e.g., such as time, speed and/or direction of travel if available) reported by the UE.

* The UE can report its position (and possibly other quantities such as time and velocity) to the gNB, and, the gNB can determine the ID of the virtual cell. The gNB can then convey such ID to the AMF via NGAP signaling.
* **Option 1a: Earth-Fixed Hierarchical Regions[14]:**

Define a hierarchical region layout to enable the gNB and/or the UE to efficiently (i) determine IDs of the virtual cells and regions and (ii) detect country border and PLMN set crossing.

* **Option 2:** **gNB finalizes CGI mapping by using V2X-like zone ID provided by UE[15]**
* **Option 3: UE report the CGI of detected TN cell as assistance information [10]**
* **Option 4: gNB finalizes CGI mapping by retrieving the UE’s location info directly from UE[9]**

Rapporteur’s comments: Any solution based on UE-generated location information for network selection purposes without verification by network is not trusted according to SA3LI. SA3-LI has the strongest requirements and we should take them into account.

**Question 2-1**: **Which mechanism option do companies prefer to address the need? Please specify the reasons or comments if any.**

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| Company | Option 1/1a/ 2/ 3/ 4/ others | Comments |
| Samsung | 1 and 1a | Option 1 is the basic recommended option. Option 1a builds on the top of Option 1 and simplifies the UE and/or gNB processing. It would consume a significant amount of processing power if a UE or a gNB has to compared the UE’s coordinates with coordinates of hundreds of VCs. Option 1a significantly reduces the amount of processed needed to identify the VC ID and correct TAC ID.  Option 3 is impractical because it would require the UE to search for TN cells, reducing the quality of service experience and draining the precious UE battery life. Furthermore, a major use case for the NTN is where TN is not available So, the option 3 will not meet the requirements.  Unless small TN cell size-like virtual/logical cells are defined, Option 4’s CGI would not meet the location accuracy requirements. If CGI is made to match the TN cell-like VCs, Option 4 would be equivalent to Option 1. |
| Sony | Option 4/1/1a | Based on the UE’s location reporting, gNB can carry out additional ID-location mapping. |
| Apple | 1/1a/3/4/Other | As discussed in our paper R2-2105117, we can try mapping the earth fixed locations to terrestrial nodes to satellite cell ID as well and use the earth fixed cell IDs as virtual cell IDs. |
| MediaTek | 4 | For Rel-17, we prefer a simple mechanism such as UE reporting its location. Further enhancements can be considered in Rel-18, when we have more time. |
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**Summary:**

## 3.3 Trustable final UE location information at the core network

### Background

SA3LI makes it clear that the UE-generated location information is unlikely to be considered reliable for network selection purposes in the reply LS [2].

* **Question 2: RAN2 would like to ask SA3 and SA3-LI to confirm whether A-GNSS based UE location information, i.e. computed at network using A-GNSS based measurements provided by UE, or computed by UE, can be considered reliable e.g. for lawful interception.**

SA3LI notes that any method which relies solely on UE-generated location information is unlikely to be considered reliable for network selection purposes. Therefore, a method such as GNSS/A-GNSS cannot be considered as reliable or trusted unless the information provided by the UE can be verified by the network. In the event that the available location information is insufficient for the AMF to determine the UE location with comparable accuracy and reliability to terrestrial networks, SA3LI considers that invocation of LCS procedures via the LMF may be necessary to fulfil regulatory obligation.

It seems that any solution if only UE-generated location information for network selection purposes is not trusted unless it is verified by network.

So companies will discuss whether RAN2 needs to do anything (and in case what) to ensure that that final UE location information at the core network is trustable.

In order to figure out the actions in RAN2 for the issue above, we will disucss following the two steps:

### Whether and who verify UE’s location

Companies will discuss whether RAN2 needs to do anything to ensure that final UE location information at the core network is trustable.

**Question 3-1**: **Does RAN2 needs to do anything to ensure that final UE location information at the core network is trustable? Please specify the reasons or comments if any.**

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| Company | Yes/No | Comments |
| Samsung | Yes | The gNB can make use of measurements provided by the UE to verify (or “do a sanity check”) the UE-reported position. Examples of measurements that can be used to validate or cross-check the UE-reported position include RSRP of the serving cell and detected neighbor cells (even weak ones to facilitate RF fingerprinting), propagation delay between the UE and the platform, and elevation angle toward the serving cell. |
| Sony | Yes | gNB may use location server to ensure that the reported UE location is trustable. |
| Apple | Yes | Measurements should be sufficient to provide this reliability the core network is seeking. The gNB can ensure these measurements are valid. |
| MediaTek | No | The network can verify the UE’s reported location based on the timing advance and how it changes for the UE. |
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The potential entity that is responsible for the verification on UE’s location is list below:

* **Option 1:** verified by gNB for UE-generated location
* **Option 2:** verified by LMF for LMF-generated (UE-Assisted A-GNSS) location
* **Option 3**: verified by LMF for UE- generated (UE-based A-GNSS) location

**Question 3-2**: **If final UE’s location should be verified by RAN2, which network node should be responsible for the verification? Please specify the reasons or comments if any.**

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| --- | --- | --- |
| Company | Option1 / 2 / 3 /others | Comments |
| Samsung | Option 1 | As we observed earlier, the gNB needs to validate the UE position first so that it can choose the correct cpore network at all times and provide TN cell-like granularity as part of ULI in NGAP signaling and indicate such validation to the AMF/5GC. |
| Sony | Option 3 | Verified based on UE’s reporting. |
| Apple | Option 1 | With Earth fixed cell IDs, gNB can use the same procedures used today for TN nodes for validation purposes. |
| MediaTek | Option 1 | This can be verified by gNB based on the timing advance information and its rate of change. |
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**Summary:**

### How to verify

If RAN2 is supposed to verify the UE’s location, there are candidate solutions in LMF for the verification.

LMF is able to calculate UE’s geographic location within the existing LCS procedure and LPP protocols specified in TS 38.305[3] and TS 37.355[4].



Figure 5.2-1: Location Service Support by NG-RAN

When UE reports the GNSS measurement to LMF (UE-Assisted mode or UE-based mode), LMF is able to calculate UE’s location by itself which is called verification.

*– A-GNSS-ProvideLocationInformation*

The IE *A-GNSS-ProvideLocationInformation* is used by the target device to provide location measurements (e.g., pseudo‑ranges, location estimate, velocity) to the location server, together with time information. It may also be used to provide GNSS positioning specific error reason.

-- ASN1START

A-GNSS-ProvideLocationInformation ::= SEQUENCE {

gnss-SignalMeasurementInformation GNSS-SignalMeasurementInformation OPTIONAL,

gnss-LocationInformation GNSS-LocationInformation OPTIONAL,

gnss-Error A-GNSS-Error OPTIONAL,

...

}

-- ASN1STOP

For more detail A-GNSS positioning method, please refer to clause 8.1GNSS positioning methods which includes 8.1.3 Assisted-GNSS Positioning Procedures in TS38.305 (stage2) [3] and clause 6.5.2 A-GNSS Positioning in TS 37.355(stage 2) [4].

However it is not clear that how gNB verifies UE’s location with gNB mapping ID [15][10][9] according to UE-generated location so far. Companies are encouraged to submit the potential verification solution here.

So here is the summary which how to ensure that final UE location information at the core network is trustable.

* **Option 1:** gNB verify the UE-generated location without clear candidate solution
* **Option 2:** LMF verify LMF-generated (UE-Assisted A-GNSS) location following existing LPP protocol
* **Option 3**: LMF verify UE-generated (UE-based A-GNSS) location by request the GNSS measurement following existing LPP protocol

**Question 3-3**: **Which option(s) do companies think work for the verification? Please specify how to verify if any.**

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| Company | Option 1 / 2 / 3 /others | Comments |
| Samsung | 1 | Make use of “RF Fingerprinting” (inadequate by itself in the NTN due to smaller RSRP differences) along with additional NTN-specific measurements such as propagation delay and elevation angle. Note that the UE does not need to keep making measurements all the time. The UE does so when certain events occur. Furthermore, the network can configure the periodicity of the UE position determination and measurement making. Additionally, reporting of the historical measurements (e.g., N samples) after an event has occurred (which points to the need for such measurements) would further increase the confidence about the validation. |
| Sony | Option 3 | We think option 3 is straightforward |
| Apple | Option 1 | Please see response to question 3-2. |
| MediaTek | Option 1 | This can be verified by the gNB implementation based on UE’s timing advance and its rate of change. |
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**Summary:**

# 4 Conclusion

TBD

# 5 References

1. R2-2104730 Reply to LS on UE location aspects in NTN (S2-2103550; contact: Thales) SA2 LS in Rel-17 5GSAT\_ARCH To:RAN2 Cc:SA3-LI, RAN3, SA3, CT1
2. R2-2102679\_ S3i210282 Reply LS on UE location aspects in NTN Tencastle
3. TS 38.305 User Equipment (UE) positioning in NG-RAN V16.3.0
4. TS 37.355 LTE Positioning Protocol (LPP) V16.4.0
5. S2-2101667 23.502 CR2482 (Rel-17, 'B'): Network selection for NR satellite access Nokia, Nokia Shanghai Bell, Qualcomm Incorporated
6. S2-2101666 23.501 CR2547 (Rel-17, 'B'): Network selection for NR satellite access Nokia, Nokia Shanghai Bell
7. TS 23.502 Procedures for the 5G System (5GS); Stage 2 V16.7.1
8. TS 23.273 5G System (5GS) Location Services (LCS); Stage 2 V16.3.0
9. R2-2104854 Discussion on reply LSs on UE location aspects in NTN CATT discussion Rel-17 NR\_NTN\_solutions-Core
10. R2-2105924 Understanding on the UE location aspects in NTN ZTE corporation, Sanechips discussion Rel-17 NR\_NTN\_solutions-Core
11. R2-2105435 UE positioning methods for NTN Qualcomm Incorporated discussion Rel-17 NR\_NTN\_solutions-Core
12. R2-2105558 Discussion on location service for NTN Xiaomi discussion
13. R2-2105935 NTN location reporting aspects Ericsson discussion NR\_NTN\_solutions-Core
14. R2-2106072 Area Management in an NTN Samsung Research America and Thales discussion
15. R2-2105610 Discussion on decoupled cell ID Huawei, HiSilicon discussion Rel-17 NR\_NTN\_solutions-Core