**3GPP T****SG-RAN WG2 Meeting #113e draft-R2-2102012**

**E-Meeting: January 25- February 05, 2021**

**Agenda item: 8.10.1**

**Source: Qualcomm Incorporated**

**Title: [AT113-e][102][NTN] Reply LSs to SA2 and RAN3**

**Document for: Discussion and Decision**

# Introduction

RAN2 has received following LSs from SA2 and RAN3.

1) R2-2100067 AN-PDB and PER targets for satellite access (S2-2009225; contact: Qualcomm) SA2 LS in Rel-17 5GSAT\_ARCH To:RAN1, RAN2 Cc:RAN3

2) R2-2011041 Reply LS on SA WG2 assumptions from conclusion of study on architecture aspects for using satellite access in 5G (R3-207062; contact: Qualcomm) RAN3 LS in Rel-17 NR\_NTN\_solutions-Core, 5GSAT\_ARCH To: SA2, RAN2 Cc: SA3-LI, SA5

In the first LS, SAs is asking expected lower bound and upper bound values for PDB and upper bound of PER when the different RAT types for satellite access is used. In the second LS, RAN2 is asking RAN2 feedback on SIB content corresponding to momentary coverage area of a satellite beam and gNB acquiring UE’s location information. Based on these LSs, following email discussion has been started.

* [AT113-e][102][NTN] Reply LSs to SA2 and RAN3 (Qualcomm)

Scope: Discuss reply LSs for [R2-2100067](file:///C:\C:\Data\3GPP\Extracts\R2-2100067_S2-2009225.doc) (AN-PDB and PER targets for satellite access) and [R2-2011041](file:///C:\C:\Data\3GPP\archive\RAN2\RAN2%23112\Tdocs\R2-2011041.zip) (SA WG2 assumptions from conclusion of study on architecture aspects for using satellite access in 5G). Note: Soft/hard TAC update will be discussed separately

Initial intended outcome: rapporteur summary and, if possible, draft reply LSs

Initial deadline (for companies' feedback): Friday 2021-01-29 10:00 UTC

Initial deadline (for rapporteur's summary in R2-2102012): Monday 2021-02-01 23:00 UTC

This document provides summary of the email discussion.

# Discussion

## LS reply to R2-2100067 (AN-PDB and PER targets for satellite access)

**SA2 Question 1: SA2 would like to ask RAN1, and RAN2 to indicate what is the expected “lower” and “higher” AN-PDB values when the different RAT types for satellite access is used?**

**SA2 Question 2: SA2 would like to ask RAN1, and RAN2 to indicate what is the expected upper bound of PER when the different RAT types for satellite access is used?**

It may be difficult to calculate the upper bound for packet delay before the packet can be considered successfully transmitted. It depends on how many RLC and HARQ retransmissions are allowed and what is the target packet error rate. For example, as described in TR 38.821, if 4 RLC retransmissions are allowed, then maximum transmission time for a packet could be 3000ms for GEO and 150ms for LEO at 600km.

If no retransmission is considered in the PDB, then the delay could be at least one maximum RTD (541.46 ms for GEO, 25.77 ms for LEO at 600km, 41.77 ms for LEO at 1200km) considering scheduling delay and the target PER would be different than what would be assumed when retransmission is allowed.

For HAPS, as propagation delay is much lower than LEO, the expected PDB can be similar to those used in TN.

1. Do you agree to suggest the expected lower bound PDB and/or upper bound PDB to SA2 for the different RAT types for satellite access?

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| Company | Yes/No | Comments |
| ZTE | No | * We understand that the services and corresponding requirements for delay and reliability supported in various NTN scenarios, e.g. GEO/LEO/HAPS based NTN with transparent payload, should be clarified in SA groups before defining the NTN specific PDB and PER. * From RAN2’s perspective, we can provide some assistance information on the maximum round trip delay for the typical scenarios we identified in the first RAN2 meeting for SA2 to take into account when the decision is made there. * We prefer not to mention the number of allowed RLC or HARQ retransmissions to avoid any unintended limitation to SA groups when the service types and corresponding requirements for NTN are discussed and decided. |
| Thales | Yes | Indeed considering the additional delay experienced in satellite access compared to terrestrial RAT, we recommend to suggest higher upper bound PDB to SA2.  We are not sure about the need to suggest specific lower bound PDB for satellite access. |
| Samsung | Yes | In general, the service performance requirements dictate target QoS parameters. However, if “relaxed QoS” compared to the currently available QoS for standardized 5QIs is adopted, there would be more flexibility in modifying parameters such as the PDB and the PER.  For several 5QIs, the gNB-UPF delay of 20 ms is assumed in TS23.501, leaving (PDB-20 ms) for the UE-gNB one-way transfer of information (e.g., downlink packet delay). For example, for 5QI=8 or 9, PDB=300 ms, leaving (AN-PDB=300-20=280 ms) between the gNB and the UE for a successful downlink packet reception at the UE (same 280 ms for the successful uplink packet reception at the gNB). The gNB needs to meet the PER requirement within the AN-PDB period.  Different NTN types/RAT types have widely different propagation delays. Additionally, compared to a TN, an NTN has (i) additional non-core network processing delays at the NTN platform (e.g., a satellite or HAPS) and the NTN-GW and (ii) the transport delay between the gNB and the NTN-GW. Hence, even if there were no additional propagation delays in an NTN, an NTN gNB would have less time compared to a TN gNB to meet the QoS requirements of a given Release 16-defined 5QI. Hence, we suggest that RAN2 and SA2 consider the concept of “relaxed QoS,” where the PDB targets and potentially some PER targets of existing 5QIs are modified for an NTN. Such “relaxed QoS” will increase the utility of the NTN, expand the NTN ecosystem, equip a service provider with flexibility to offer diverse services, and provide the NTN gNB more flexibility in meeting the required QoS efficiently (i.e., using fewer radio resources).  In particular, we see the benefits of increasing the PDB for at least these 5QIs: (i) 5QI=1 for GBR voice services, (ii) 5QI=3 for real-time gaming, (iii) 5QI=5 for IMS signaling, and (iv) 5QI=8 or 9 for buffered streaming and TCP-based applications such as email and WWW. In our view, “relaxed QoS” would enable HAPS and LEOs in lower orbits to support 5QIs=1, 3, and 5.  We offer following observations regarding the estimation of lower and upper bounds for the PDB.  For the upper bound on the PDB, Qualcomm-suggested values can be used as the baseline for the round trip propagation delay and some round trip processing delay (e.g., X ms such as 10 ms) can be added to calculate the total UE-gNB round trip delay. While the processing delay can be ignored for GEOs, it may not be negligible compared to the total propagation delay for HAPS and LEOs in lower orbits. We can multiply the total UE-gNB delay by 4 as mentioned above by Qualcomm to reflect the maximum number of target RLC retransmissions. We observe that such upper PDBs would be relevant to some 5QIs and not all 5QIs. For example, the upper PDB target value would be suitable for services such as those associated with 5QI=8 or 9. However, the upper PDB target value would not be suitable for those associated with 5QI=1 and 3, because the RLC retransmissions would not be suitable for such services.  For the lower bound, we can ignore all processing delays for simplicity (or assume minimal processing delay) and use one-way propagation delay. In our view, one-way delay would be more appropriate than the round trip delay while calculating the lower bound, because there is a high probability (e.g., 90%) that the packet is received correctly in the first transmission itself. Note that the target BLER at the physical layer for a given CQI is typically 10%.  We observe that the PDB and the PER are related to each other. For example, a larger PDB value enables a lower PER to be achieved because of more opportunities for HARQ/RLC retransmissions. |
| Huawei, HiSilicon | No | Firstly, in RAN2 we only have one RAT, i.e. NR. And we don’t have the agreement to introduce “different RAT types for satellite access”.  Secondly, we think the PER and PDB are relevant. Lower PER means more retransmission is needed, therefore longer transmission delay can be foreseen, and vice versa. The two questions asked by SA2 is actually one question, i.e. the range should be from (minimum PER value, maximum PDB) to (maximum PER, minimum PDB). And this kind of evaluation should be done by RAN1. In the reply LS, we can mention this understanding and leave it to RAN1 to provide the exact PER and PDB values. |
| Qualcomm | No | We will be ok for now just to indicate what is worst-case round-trip time delay. There may be no definitive answer to what could be the upper bound and lower bound of PDB as it depends on the assumption of number of HARQ retransmissions and RLC retransmissions.  Anyway, such 5QIs can be provided dynamically to UE. |
| Nokia | Yes | We believe this is what SA2 actually asks for, so why do we need to agree whether RAN2 can respond in such a way?!  SA2 asks for the ‘’expected low and high value’’, so we think it is OK to indicate what the rapporteur described directly prior to that Discussion point. Namely, fine to indicate the value of 3000 ms assuming the maximum number of RLC retransmissions is used. Similarly, the minimum value shall be given, for each scenario separately.  In addition, we want to ask the companies to consider if DL and UL shall be listed separately and for example the delay related to SR (in UL) should be also taken into account? |
| Spreadtrum | Partly Yes | Considering the huge difference of transmission delay for GEO and LEO cases, it is good to suggest at least the lower bound PDB to SA2. In the session setup procedure, gNB acquires the PDB value of session, selects the GEO/LEO cell, and determines the RLC retransmission and HARQ retransmission scheme for the session. |
| OPPO | No | As stated in TS23.501:  “The 5G QoS characteristics should be understood as guidelines for setting node specific parameters for each QoS Flow e.g. for 3GPP radio access link layer protocol configurations.”  We think it should be SA2 to discuss and decide the target PDB requirement. Then the Uu’s configuration parameters such as maximum ARQ retransmission number are configured by taking this target PDB into account.  Due to a much larger propagation delay in some NTN scenarios such as GEO and LEO compared to TN, the PDB requirement should take this [non-negligible](javascript:;) propagation delay into account. From RAN2’s perspective, we could just provide the delay related information, e.g. maximum RTD for different NTN scenarios, to SA2. |
| MediaTek | No | While we cannot define PDB and PER values in RAN2, we can provide assistance information to SA2 on the impact of RTT, for example typically one RTT will correspond to a PER of 10-1 |
| Xiaomi | No | We think it should be decided by SA2 and RAN2 can provide information to SA2. |

1. If answer of Discussion point 1 is “No”, please elaborate how to reply to SA2 regarding the value of the expected PDB for the different RAT types for satellite access?

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| Company | Comments |
| ZTE | Our draft reply can be found in R2-2101200:  *RAN2 understand the services and corresponding requirements for delay and reliability supported in various NTN scenarios, e.g. GEO/LEO/HAPS based NTN with transparent payload, should be clarified in SA groups before defining the NTN specific PDB and PER.*  *Regarding the AN-PDB, RAN2 would like to provide the following assistance information for SA2 to make decision:*   * *The maximum round trip delay between UE and the NTN-GW would be 25.77ms (600km-LEO based NTN with transparent payload) ~ 541.46ms (35786km-GEO based NTN with transparent payload). The case where gNB is co-located at the NTN-GW is considered with priority in RAN2, in which the propagation delay between NTN-GW and the gNB can be ignored.* * *RAN2 understand the propagation delay in HAPS based NTN with transparent payload would be similar to that in TN.* |
| Huawei, HiSilicon | In the reply LS, we can mention this understanding and leave it to RAN1 to provide the exact PER and PDB values. This reply LS can also CC RAN1.  For example:  *RAN2 understand the PER and PDB are relevant. Lower PER means more retransmission is needed, therefore longer transmission delay can be foreseen, and vice versa. The range should be from (minimum PER value, maximum PDB) to (maximum PER, minimum PDB). And RAN1 can provide the exact minimum and maximum values.* |
| Qualcomm | SA2 has not asked lower bound of PER. We can provide straightforward answer.  *RAN2 would like to inform that worst-case round-trip delay in NTN with transparent payload is 541.46 ms for GEO, 25.77 ms for LEO at 600km, and 41.77 ms for LEO at 1200km. RAN2 understand the propagation delay in HAPS based NTN with transparent payload would be similar to that in TN* |
| OPPO | Agree with ZTE.  We could provide the maximum RTD for different NTN scenarios to SA2, which would be helpful for them to make decision. |
| MediaTek | We should provide SA2 for RTT values of GEO and LEO, i.e. 541.46 ms for GEO, 25.77 ms for LEO at 600km, and 41.77 ms for LEO at 1200km and indicate that this RTT values correspond to a single transmission, which would typically experience a failure rate of 10-1. SA2 can use this information to determine appropriate PDB and PER values for NTN deployment. |
| Xiaomi | We agree with ZTE. |

1. If answer of Discussion point 1 is “Yes”, please elaborate what value to indicate to SA2 for the different RAT types for satellite access?

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| Company | Comments |
| Thales | Compared to terrestrial networks, the GEO based NR access (NTN’s worst case in terms of round trip delay) will add a further delay of 541.46 ms compared to the RTD of cellular networks (see Table 4.2-2: Reference scenario parameters of TR 38.821)  If we assume a maximum of “n” RLC retransmissions, the current upper bound PDB should be increased by 2\*(n+1) times the maximum propagation delay (one way) of the satellite access. |
| Samsung | As we observed in Discussion Point 1, the service performance requirements typically dictate target QoS parameters. However, if “relaxed QoS” compared to the currently available QoS for standardized 5QIs is adopted, there would be more flexibility in modifying parameters such as the PDB and the PER.  We have suggested a framework in our response to Discussion Point 1. Once companies express their views about the overall framework and agree with assumptions related to # of RLC retransmissions, LEO altitude, MEO altitude, and HAPS altitude assuming OTHERSAT=HAPS, and processing delay if non-negligible, RAN2 can calculate the lower and upper PDB values.  To facilitate implementation of relaxed QoS and to provide adequate flexibility to the gNB design, scaling factors can be used to modify Release 16-defined PDB and PER targets. We prefer not to constraint the achievable PDB and PER in a given NTN Type deployment by assuming the worst case of other NTN/RAT types. Hence, in our view, defining scaling factors and their ranges may be more suitable for NTN QoS.  Example Draft Reply Text. “RAN2 has observed that different adjustments to the Release 16-defined PDB targets and PER targets are needed for (i) different NTN Types/RAT Types and (ii) different 5QIs. Suggested scaling factors and associated PDB and PER targets for selected 5QIs are given in Table Y.”  Table Y: TBD based on RAN2 agreements on assumptions. An example Table Y is given below for 5QI=8 or 9 for GEO, MEO (altitude= A1 km), LEO (altitude = A2 km), and HAPS (altitude=A3 km) and the processing delay of P ms. The value of AN-PDB for an NTN can be calculated as (NTN PDB - 20 ms) for 5QI=8 or 9. In Table Y below, SF stands for Scaling Factor.   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | 5QI | R16 PDB | NTN PDB | R16 PER | NTN PER | Comments | | 8 or 9 | 300 ms | SF1\*300 ms | 10-6 | SF2\*10-6 ms | SF1=X1 for GEO, SF1=X2 for MEO, SF1=X3 for LEO, and SF1=X4 for HAPS.  SF2= 1 is likely to suffice with 2 RLC (re)transmissions and 3 HARQ (re)transmissions for each RLC transmission. Assumption: 2\*3=6 independent transmissions. Since HARQ allows soft combining, this would be a pessimistic assumption. Independent packet error probability of 10% is assumed at the PHY layer. |   We observe that the PER of 2% or 3% corresponding to SF= 2 or 3 could work just fine and may be acceptable to service providers for an NTN when 5QI=1 is used to support voice services. |
| Nokia | The values from Table 4.2-2 in 38.821 are OK if we do not consider the DL/UL differentiation and the time needed for scheduling etc. In addition, the maximum values indicated by the rapporteur, when retransmissions occur, shall be inserted. |
| Spreadtrum | For GEO case, at least additional delay of 541.46ms shall be added to PDB, if no RLC retransmission is assumed.  For LEO case, at least 25.77ms shall be added. |

The target PER may be different depending on whether the PDB considers retransmissions. However, Rapporteur thinks RAN2 is not in the position to suggest the value of the expected PER.

1. Please elaborate how to respond to SA2 on the expected upper bound of PER when the different RAT types for satellite access is used?

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| Company | Comments |
| ZTE | Regarding PER, although there have been agreements made in RAN1 and RAN2 on disabling HARQ feedback for downlink, the HARQ retransmission and RLC ARQ would still be supported in NTN to ensure the reliability.  Thus, we understand the PER for a certain service, if supported in NTN, would be similar to the corresponding PER in TN. |
| Thales | The upper bound of PER should be provided by RAN1 |
| Samsung | We think RAN2 can provide views for SA2’s consideration.  Example Draft Reply Text. “RAN2 has observed that different adjustments to the Release 16-defined PDB targets and PER targets are needed for (i) different NTN Types/RAT Types and (ii) different 5QIs. Suggested scaling factors and associated PDB and PER targets for selected 5QIs are given in Table Y.”  As mentioned in our response in Discussion Point 1, we observe that the PDB and the PER are related to each other. For example, a larger PDB value enables a lower PER to be achieved because of more opportunities for HARQ/RLC retransmissions. Assuming the maximum/typical number of RLC and HARQ retransmissions, we can calculate the PDB. Then, within the PDB, we can verify if the PER is achievable or not with the potential help from RLC and HARQ retransmissions where appropriate for a given 5QI. Furthermore, where feasible, RAN2 can suggest an increase in the PER to give the gNB more flexibility in meeting the target PER while minimizing the radio resource utilization.  At this time, RAN2 is aware of (i) additional propagation delays in an NTN compared to a TN, (ii) additional processing delays in an NTN compared to a TN, (iii) widely varying propagation delay differences among different NTN Types, and (iv) different PER tolerances of different services.  The NTN-Type-based and the 5QI-based scaling factors will enable the gNB network to meet relaxed QoS requirements for a given NTN Type. Furthermore, such flexibility will enable the NTN ecosystem to flourish by empowering the NTN to support applications such as real-time gaming and voice services for HAPS and (at least) LEOs in lower orbits in addition to TCP-based applications for all NTN Types. |
| Huawei, HiSilicon | The upper bound of PER should be provided by RAN1 |
| Qualcomm | It is true RAN1 should provide this value but we think it is OK to let them know RAN2’s expectation.  *The expected upper bound of PER depends on whether the expected value of PDB considers retransmissions. RAN2 expects the same TN upper bound of PER to be applicable in NTN. If HARQ retransmission is disabled, this can be achieved with additional PHY layer enhancements which is outside the RAN2 scope.* |
| Nokia | In principle fine with ZTE’s answer. We should, however, indicate the lower PER target, the more likely it is a retransmission will be essential. |
| Spreadtrum | Based on the upper bound of BLER provided by RAN1, the value of PER depends on the maximum retransmissions in RAN, which is based on PDB and RTD. |
| OPPO | The upper bound of PER should be provided by RAN1. |
| MediaTek | The upper bound of PER is typically a function of PDB. RAN1 can provide appropriate values here. |
| Xiaomi | We think it should be decided by RAN1. |

## LS reply to R2-2011041 (SA WG2 assumptions from conclusion of study on architecture aspects for using satellite access in 5G)

RAN3 agreed that a Cell ID as used in the User Location Information on the NG/N2 interface corresponds to a fixed geographical area, and the Tracking Area is coupled with geographical area. RAN3 has asked feedback on the following approach (a) and approach (b).

**Approach a)** On Uu, SIB content corresponds to momentary coverage area of a satellite beam related to the geographically fixed areas of TAs/Cells - irrespective of whether the beam is fixed or moving.

As mentioned in [1], the SIB content, i.e., broadcast TAC and cell ID correspond to momentary coverage area of a satellite beam. The cell ID is changed as soon as the cell enters a new area. But in [2], the multiple cell IDs can be broadcast, and boundary of each cell can be provided to the UE. The UE can select the cell based on its geographical area. In [3], multiple cell IDs are broadcast and fixed association between tracking area and cell ID is used.

However, in any case, SIB content (cell identity) would need to be changed when a cell enters a new area. This contradicts with the following clarification RAN2 made in [4].

*A moving radio cell covers different earth area over time and system information including Cell ID moves with the radio cell.*

1. Please provide comment on how to respond to the approach (a)?

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| Company | Comments |
| ZTE | We understand approach a) is not workable for the earth moving scenario as the coverage of the satellite beam change when the satellite sweep on the ground thus it would be quite difficult for NW to broadcast a cell ID correspond to momentary coverage area of a satellite beam.  Our understanding on the cell ID broadcast in earth fixed and moving scenario is shown below: |
| Thales | On Uu, the cell Id in SIB should corresponds to a beam foot print or a set of beam footprint. Hence Cells move with the beam footprint on Earth |
| Samsung | Draft Reply Text:  “RAN2 would like to kindly inform RAN3 that changing the cell-based SIB content dynamically to uniquely match a hypothetical Earth-fixed cell on the ground is quite challenging in case of Earth-moving beams and possibly quasi-Earth-fixed beams. Hence, RAN2 plans to move the SIB content along with the cell from one geographic area to another in case of moving NTN beams/cells.”  Details of the Response to RAN3:  “RAN2 observes that an Earth-moving cell would often cover two or more hypothetical Earth-fixed cells and that the SIB content reflects unique cell-specific parameters. The gNB transmits and receives cell-specific signals, and, such cell moves from one geographic area to another as a function of time in case of moving cells/beams. The gNB identifies each cell by a PCI (Physical Cell Identifier) that is locally unique and an NCGI (NR Cell Global Identity) that is globally unique. The SIB content is cell-specific and many radio interface signals are a function of the PCI. Hence, the gNB needs to maintain the same cell ID even when the cells move. When an NTN cell covers multiple hypothetical Earth-fixed cells, the gNB cannot determine what PCI/NCGI to use to process downlink and uplink signals if the gNB does not have a fixed cell ID on the radio interface.” |
| Huawei, HiSilicon | Postpone this discussion until we have an agreement on soft TAC update or hard TAC update. We see approach (a) is the same mechanism as TAC update. Actually the “Cell ID as used in the User Location Information” is still TAC but with a finer granularity considering a geo-fixed TAC could insists of several Cell IDs.  The solution provided in [1] is hard Cell ID update, while the solutions in [2] and [3] are soft Cell ID update. As we already started offline-104 for TAC update, we suggest to reuse the conclusion made in that offline discussion to avoid duplicate discussion. |
| Qualcomm | We should update RAN3 and not try to delay NTN progress.  *RAN2 has already clarified that the SIB content including cell identity also moves along with beam in case of moving beams. In case of fixed beam, the SIB content and cell identity are not changed for a beam in a given geographical area unless the beam is switched off. How a TAC is updated depends on the solution agreed for hard TAC update or soft TAC update which is still being discussed in RAN2.* |
| CATT | We do not see any benefit to broadcast geographical fixed CGI in Uu interface, and frequently SI update seems needed in case of earth moving cell. We understand the cell Id in SIB should corresponds to the real coverage of a physical cell (a beam foot print or a set of beam footprint). |
| Nokia | Agree with ZTE. We think option a) is quite complex and not feasible due to the need to continuously change the Cell ID broadcasted in SI. |
| Spreadtrum | It is difficult to map the cell Id in SIB to a moving beam foot print or a set of moving beam footprint. |
| OPPO | We tend to share Huawei’s understanding. Approach (a) is very similar to TAC update and we propose to postpone the reply before RAN2 has clear views on TAC update. |
| Fraunhofer | We agree with Huawei. Let’s wait until a solution for the TAC update is agreed. In our understanding the TAC update mechanism could maybe be reused for updating the Cell ID |
| MediaTek | We agree with Thales and Qualcomm that the cell Id in SIB should correspond to a beam foot print or a set of beam footprint. Hence Cells move with the beam footprint on Earth. |
| Xiaomi | It is complicated for the earth moving beam case.  For earth fixed beam case, it seems that Approach a) is feasible. |

**Approach b)** The cell ID used on Uu SIB content (and probably on Xn) are decoupled from cell ID used on NG(N2). The respective mapping is performed in RAN. This requires gNB to acquire the UE’s location information.

In this approach, RAN will construct a fixed cell identity to be provided to AMF and this cell identity may not be same as the cell identity that is being broadcast in cell. Therefore, RAN would need UE location information to create a cell identity that corresponds to a fixed geographical area.

When AS security is not enabled, i.e., when constructing the fixed cell identity, for example to be used in “User Location Information” in “INITIAL UE MESSAGE” after UE sends the Msg5, RAN may consider following information to determine the fixed geographical area.

* 1. Broadcast PCID/cell ID
  2. Broadcast TAC
  3. Satellite beam coordinates
  4. Time stamp

However, there is a problem when relying only on this information.

**Problem:** The size of geographical area that RAN determines for the fixed cell ID may be too large. When a satellite beam spills over multiple countries, the geographical area identified from the above-mentioned information may not correspond to the country where UE is physically located. This may bring issues like paging and incorrect charging. The UE registered in country A may access the core network of the same country A (sounds correct!) while the UE is physically located in different country B (but not correct!) if moving NTN cell covers both country A and B. This will be against the following fundamental LI requirements for NTN indicated by SA3-LI in [5].

* *Any solution shall support the ability to enforce the use of a Core Network of PLMN in the country where the UE is physically located. The enforcement needs to also include cross-border service continuity scenarios.*

1. Do you agree that severity of problem of cell coverage spill over multiple countries is worse than what is today for terrestrial network?

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| Company | Yes/No | Comments |
| ZTE | / | This is not related to the content of RAN3 LS and is out of the scope of this offline discussion. |
| Thales | Yes | One should distinguish between 4 most likely NTN scenarios:   * GEO providing Earth fixed beams (and cells) of large size spanning across multiple countries to serve “VSAT” type terminal with broadband services => The enforcement of LI requirements will require additional location related information to determine in which country the UE is with sufficient accuracy. * LEO providing Earth fixed beams (and cells) of size comparable to maximum size of terrestrial networks’ cells (e.g. super cells) to serve handset or “VSAT” type terminal with broadband services => The enforcement of LI requirements may raise similar needs in terms of additional location related information as for terrestrial networks * LEO providing Earth moving beams (and cells) of large size spanning across multiple countries to serve IoT devices with narrowband services => Not sure that LI requirements applies to IoT services. * HAPS providing Earth fixed or moving beams (and cells) of size comparable to maximum size of terrestrial networks’ cells (e.g. super cells) to serve handset with broadband services => The enforcement of LI requirements may raise similar needs in terms of additional location related information as for terrestrial networks |
| Samsung | Yes | In a TN, it is relatively easy to carry out radio network planning and design such that a cell near the border between the countries only covers the target country. For example, antenna down-tilting and antenna height can be adjusted to ensure that the RF coverage of the cell of one country/PLMN does not spill into another country.  In an NTN with Earth-moving beams (and to some extent quasi-Earth-fixed beams), confining coverage of a cell inside a specific country is not practical, because an attempt to do so will create a huge area (i.e., the size of the cell such as a cell with the 1000 km diameter) without any service. Hence, a solution that minimizes such “no man’s land” or “buffer zone” is desirable for an NTN. |
| Huawei, HiSilicon | Yes | It’s quite likely that one NTN physical cell covers several countries. |
| Qualcomm | Yes | Due to the following reasons, this problem is worse in NTN compared TN.  1. The NTN cell size can be very large in hundreds of kms compared to TN cell that is in tens of kms or less.  2. The moving cell keeps moving on earth and may frequently cross international borders. At a point of time, for example, this may result in 50% of cell coverage in country A and 50% of cell coverage in country B. |
| CATT | Yes | UE can be pre-configured a “map” including the mapping of PLMN (MCC) and the boundary of the countries. As GNSS capability is assumed for the NTN UE in Rel-17, UE should be able to select the correct PLMN associated to the country it’s located in case of cell coverage spill over multiple countries.  And then, gNB can select the correct AMF according to the selected PLMN provided in *RRCSetupComplete* message.  We should notify RAN3 the PLMN selection for NTN should be done by considering the UE location information. |
| Nokia | No | Even in terrestrial networks such problem of accessing the CN not corresponding to the actual UE’s location (at the country border) is present, so not sure why do we address it here? We agree with ZTE, this is not directly linked to what has been asked by RAN3. |
| Spreadtrum | Yes | NTN cell is much larger than TN cell. The maximum beam footprint size of LEO may cover multiple countries. |
| OPPO |  | Agree with ZTE. This is not related to RAN3 LS. |
| MediaTek | Yes but | This is an issue for RAN3 and CT1 to resolve. |
| Xiaomi | Yes | The NTN cell may cover multiple countries. |

To reduce the severity of the problem, RAN may need additional location related information other than the above information (i.e., cell ID, TAC, beam coordinate and time stamp). For example, the UE specific TA reported by UE in MsgA/Msg5 can help RAN determine whether the UE is close to the beam center.

1. Do you agree that RAN requires additional location related information other than the broadcast cell ID, broadcast TAC, beam coordinates and time stamp to reduce the problem of satellite beam spill over multiple countries?

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| Company | Yes/No | Comments |
| ZTE | / | This is not related to the content of RAN3 LS and is out of the scope of this offline discussion.  So far, no clear need for RAN to acquire additional UE location info has been identified. |
| Thales | Yes | Yes in accordance with SA2 requirement in agreed CR in S2-2009486, “Selection of CN node by NG-RAN node providing satellite access across multiple countries”, Ericsson |
| Samsung | Yes | Here is an example procedure that can help address the country border scenario.  1. The UE reports its GNSS-based position and configured measurements such as historical (i.e., multiple samples at different instants) RSRP and UE-NTN platform delay. This delay should preferably be based on the transmit time broadcast by the gNB and the receive time at the UE to remove dependence of the delay on the UE-reported position. Any measurements that are calculated without using the UE-reported GNSS-based location would be highly useful and should be discussed (e.g., TA if it is not calculated using the UE-reported GNSS-based location). Identities of these measurements are FFS.  2. The gNB validates the UE-reported position using UE-reported historical RSRPs and time delays and reports such validated position to the AMF of the correct PLMN. FFS if the gNB can block a UE trying to connect to an incorrect PLMN or the gNB needs to let the core network take care of such blocking by following the traditional approach. The gNB may also report a virtual cell ID associated with the Earth-fixed cell and possibly characteristics of such cell (e.g., cell center and cell radius of a hexagon-shaped virtual cell or cell center, major axis, and minor axis of an elliptical virtual cell). The virtual cells can match the beam shape or can be completely independent of NTN beams/cells. Such virtual cells can be made arbitrarily small to obtain the positioning “cell-level granularity” that is comparable to the “cell-level granularity” in a TN.  3. The gNB can use the validated UE position to perform RAN functions per policy/previsioning or under the explicit directions from the core network.  4. The core network (e.g., AMF) can use the validated UE position and possibly virtual cell ID specifics to perform PLMN-specific functions such as registration and registration updates and to possibly provide updated PLMN-specific policies to the gNB.  To enhance cell reselection by idle/connected mode UEs and to facilitate cross-border UE movements, the gNB can perhaps convey the availability of PLMNs to UEs (e.g., PLMN P1 is available till t1 and PLMN P2 will be available after t2 via this cell). Note that some UEs may have a valid authorization for PLMNs of different countries and some may not.  We suggest that RAN2 discuss the country border issue further to develop a robust solution. |
| Huawei, HiSilicon | / | We think the location based assistance information is used by core network to determine if UE selects a proper PLMN aligned with its location. So it should be accurate enough or with a finer granularity than a country. If current TAC or cell ID corresponds to a smaller area than a country, and thus sufficient to determine which country UE is located in, it would be applicable. Then no other assistance information is needed. This understanding can also be confirmed by offline-104. |
| Qualcomm | Yes | Issue is TAC and cell ID may not be enough to determine in which country UE is located. That’s reason we are having this conversation. If satellite beam does not spill over multiple countries in a worse way than in TN, there may be nothing to do in RAN2.  Any helpful information that comes with minimal impact should be considered.  1. The UE specific TA reported in MsgA/Msg5 helps RAN to determine how far the US is from cell center. If UE is closer to beam center, then area determined from the UE specific propagation distance could be in a country A even though the beam is spilled over country B.  2. The UE could report one strongest physical cell ID (PCID). This will help RAN to guess in which direction UE is in from the beam center. |
| CATT | case by case | If option b) is adopted, the UE location info (GNSS) is needed for gNB to map the UE location to the geographical fixed CGI to 5GC, which is required by SA2.  But for the cross-border issue discussed above, we understand the selected PLMN provided by UE has already taken the UE location into account, no need additional info for the gNB to do perform the NNSF correctly.  A question here is whether need to consider the “rouge” UE which selects a wrong PLMN than the one of the country it’s located. RAN2 should first clarify this. |
| Nokia |  | In case option b) is adopted then there may be an ambiguity when Cell ID broadcasted via Uu temporarily overlaps with e.g. two Cell IDs, fixed on the ground/reported to the CN. When Msg5 is sent then the NW already knows UE’s Cell ID (broadcasted over Uu), so likely this kind of information will not bring any extra value. |
| Spreadtrum | Yes | The broadcast cell ID, TAC, beam coordinates and time stamp are not enough for RAN to deduce the country in which UE is located. |
| OPPO | No | Agree with ZTE. This is not related to RAN3 LS. |
| Fraunhofer | Yes | We agree that we need a reliable additional source for acquiring User location information. Maybe we shall wait for the outcome of agenda item 8.10.3.4 LCS Aspects.  The question to be addressed is the needed accuracy of determining this location and the level of trustworthiness. Here we might set the same requirements as in terrestrial networks. |
| MediaTek | Potentially Yes, but | This is an issue of RAN3 and CT1 to resolve. Our understanding is that CT1 are discussing this topic. |
| Xiaomi | May be | We share the same view with HW, if TAC corresponds to a smaller area than a country, the additional location information is not needed. So we should decide TAC firstly. |

1. If your answer to the discussion point 7 is “Yes”, do you agree to inform RAN3 on possible RAN2 impact of the approach (b)?

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| Company | Yes/No | Comments |
| Thales | Yes |  |
| Samsung | Yes | We should certainly inform RAN3 about the country border issue and possible candidate solutions being considered in RAN2.  Additionally, we can ask RAN3 the exact reason/use of “fixed cell ID” on N2 interface (e.g., in INITIAL UE MESSAGE). In general, for Earth-moving and quasi-Earth-moving cells, the relationship between the NTN cell and a geographic area covered by such cell keeps changing from one instant to another. As long as such time-area mapping is known to all gNBs and the core network (e.g., AMF), there is no need to have a fixed cell ID on the N2 interface. The combination of (time stamp, NCGI) and validated UE-reported GNSS position should suffice on the N2 interface. Of course, if the TN-like cell-level granularity is needed by the AMF, we can certainly make use of the hypothetical Earth-fixed virtual cells that have nothing to do with the coverage of actual NTN cells! In such case, the gNB can report the virtual cell ID (and possibly characteristics of such cell) to the AMF.  For paging, the AMF does not need to know the virtual cell ID, because paging makes use of the TAI List. A suitable TAI list and (time stamp, TA) mapping would be adequate for the AMF to send a page message. If the AMF wants to use the virtual cell ID to contact a suitable gNB or NCGI, it will need (time, virtual cell ID, NCGI) mapping.  We note that RAN2 is covering the TA management topic in another email discussion. |
| Qualcomm | Yes | We should let them know what RAN2 can do and what could be expected for RAN to determine the country where UE is physically located for the initial access (i.e., before AS security is enabled). |
| CATT | / | We should inform RAN3 the UE PLMN selection for NTN should be done by considering the UE location information, this could make gNB correctly select the AMF and satisfy the requirement of SA3-LI. |
| Nokia |  | We can inform about the ambiguity we mentioned in Q7. |
| Spreadtrum | Yes |  |
| Fraunhofer | / | RAN3 is already aware of the cross-border issue as they capture this in an offline discussion with a specific agenda item called country specific routing.  In our understanding, the cross-border issue also occurs in approach a) so this is not only related to approach b). |
| MediaTek | No | RAN3 and CT1 are already aware of the cross-border issue. Once they decide on a solution, we can discuss its potential RAN2 impacts. |

1. Please indicate your view how to respond to approach (b) in the RAN3 reply LS? Also indicate which approach (a) or (b) is better.

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| Company | Comments |
| ZTE | As mentioned under discussion point 5, approach a) is not workable for the earth moving scenario as the coverage of the satellite beam change when the satellite sweep on the ground thus it would be quite difficult for NW to broadcast a cell ID correspond to momentary coverage area of a satellite beam. Thus, approach a) is not preferred.  For option b), we understand it is the geographical area information of the cell coverage that is needed for RAN to map this area to a cell ID used on NG interface.  But it can be achieved in various ways if the geographical area information of the cell coverage is needed in CN:   * Option 1: The RAN node derive the geographical area information of the cell coverage based on the satellite ephemeris, beam information and cell deployment information and map this area to a cell ID used on NG interface. * Option 2: The CN acquire the UE location information to identify the cell coverage. * Option 3: The RAN node acquire the UE location information to identify the cell coverage.   We understand that if CN needs the UE location, CN can acquire such information itself.  If it is the geographical area information of the cell coverage that matters, the RAN node is able to derive this area information (i.e. option 1) and map to a corresponding cell ID used in NG interface.  With the above understanding, we do not see the need for RAN to acquire the UE location information. |
| Thales | The most elegant solution is to define cell Id at Uu which corresponds to beam/set of beams and hence both are moving on Earth.  It is up to RAN3 to map Cell Id at Uu with Cell Id at NG. |
| Samsung | Given two choices (a) and (b), we prefer (b).  Approach (a) is impractical and unnecessarily complex in our view.  Approach (b) is feasible although it may or may not be necessary depending upon how such info is actually used by the core network.  If RAN2 must have a “fixed cell ID” on the N2 interface, the concept of a virtual cell can be used. However, such cell would have nothing to do with any NTN cells. To actually make use of such “fixed cell ID,” the core network would need to have (time, NCGI/gNB, virtual cell ID) mapping if the core network needs to communicate with a gNB that is currently covering a given virtual cell.  A benefit of the virtual cell is that the “TN-like cell-level granularity” requirement can be met. We note that the validated UE position would provide much finer position resolution compared to the cell-level granularity offered by the virtual cell ID approach. In any case, the AMF would most likely need (time, position such as UE position or NCGI, gNB) mapping to make use of any “position” it receives in NAS messages such as “Initial UE Message” if the core network needs to communicate with a gNB that is currently covering a given virtual cell. |
| Huawei, HiSilicon | We think further discussion is needed. At least the conclusion from offline-104 will affect our feasibility analysis of approach (a). As for approach (b) we also need to confirm if the TAC or cell ID can be smaller than a country, if this is the case with the UE reported TAC or cell ID RAN can use it to indicate UE location. |
| Qualcomm | We can respond as follows:  *Changing cell identity may result in change in SIB content when cell enters a new area in approach (a). This could require UE to acquire SIB. Therefore, RAN2 prefers approach (b) over approach (a).*  *RAN2 will work on methods for positioning of UE that will provide an accuracy comparable with the positioning accuracy of terrestrial networks when UE is in RRC\_CONNECTED and AS security has been enabled.*  *When AS security has not been enabled, for example to provide a cell ID and TAC to the CN in the initial UE message, RAN2 will work on solution for UE to report any additional location information (e.g., MCC, neighbour cell measurement information, geographic location coordinates, direction from beam center etc.) in MsgA/Msg5 to help RAN determine/confirm the country of presence and cell ID and TAC.* |
| CATT | We prefer approach (b)  Compared to a), we see the option b) has no impact to Uu interface. The mapping between UE location info and the geographical fixed cell ID can be performed by gNB, details is up to RAN3. |
| Nokia | We have analysed this topic in our paper R2-2100529. We think RAN2 shall indicate approach b) as the preferred one, having no big impact on Uu. Cell ID in Uu + the timing information should be sufficient to map the UE to the proper ‘fixed’ Cell ID (CN-level). |
| Spreadtrum | We prefer approach (b).  Approach a) is complex for moving beam case.  With UE location report, RAN could map to the fixed cell which is indicated in N2 interface. The accuracy of this solution is independent to TAC or cell size. |
| OPPO | For approach (a), we postpone reply until RAN2 has clear understanding on TAC update.  For approach (b), maybe we can reply to RAN3 that it is feasible from RAN2’s perspective. |
| Fraunhofer | We also see there might be difficulties in approach a) but we agree with Huawei and OPPO to wait of the outcome of [Offline-104] first.  Regarding approach b) we would like to clarify whether it is assumed that the broadcasted Cell ID does not change at all (i.e. it is still the same after multiple revolutions around earth) for a specific satellite. |
| MediaTek | We can respond to RAN3 that approach a) is not desirable from RAN2 perspective. |
| Xiaomi | We prefer approach b.  We can reply to RAN3 that approach a) is not feasible for the earth moving beam case and approach b is feasible from RAN2 perspective. |

# Conclusion

TBD..

# References

[1] R2-2100348, NTN location reporting and network identifiers, Ericsson.

[2] R2-2100330, Discussion on geographical fixed CGI, CATT.

[3] R2-2100582, NR-NTN: Cell ID Handling, Fraunhofer.

[4] R2-2008229, LS Reply on SA WG2 assumptions on architecture aspects for using, Qualcomm Inc.

[5] R2-2006532, Response LS on the “LS OUT on Location of UEs and associated key issues” (S3i200056; contact: Rogers), SA3-LI.