3GPP TSG-RAN WG2 Meeting #113 R2-20xxxxx

Elbonia, Online, 25 January – 5 February 2021

**Agenda item: 8.10.x**

**Source: Nokia, Nokia Shanghai Bell**

**Title: Report from [Post112-e][153][NTN] Idle mode aspects (Nokia)**

**WID/SID: NR\_NTN\_solutions-Core - Release 17**

**Document for: Discussion and Decision**

# 1 Brief scope of the paper

This document aims at collecting companies’ views regarding the Rel-17 NTN Idle mode:

* [Post112-e][153][NTN] Idle mode aspects (Nokia)

Scope: Discuss: 1) options for "NTN indication" 2) provision of ephemeris and 3) cell (re)selection principles, trying to resolve the FFS from the meeting agreement

Intended outcome: email discussion report

Deadline: Long

The following sections discuss those listed topics, based on RAN2 contributions submitted so far.

# 2 Agreements related to NTN Idle mode

A good starting point would be to list the Rel-17 NTN Idle mode related agreements taken so far in RAN2. These are provided in the box below:

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| **RAN2#111:**  1. Cell selection / reselection in NR is the baseline in NTN idle mode procedure.  2. Satellite/HAPS ephemeris based cell selection and reselection should be defined for NTN (FFS what the term satellite/HAPS ephemeris actually means). FFS when this ephemeris based cell selection / reselection can be used. FFS whether UE location (and/or other information) based cell selection and reselection should be introduced for NTN  3. The satellite ephemeris should be provided to UE, at least for Satellite/HAPS ephemeris based cell selection and reselection (FFS what the term satellite/HAPS ephemeris actually means).  4. The network type (i.e. TN or NTN) should be known to UE. FFS whether to achieve this in an implicit or explicit way.  5. The existing cell reselection priority configuration can be taken as a baseline in NTN. FFS on any further enhancement.  6. Postpone the discussion on whether to introduce a new SIB until we have more progress on the content of NTN specific system information. |

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| **RAN2#112:**  1. Existing cell reselection principles are considered as baseline and that information about when a cell is going to stop serving the area and information about new upcoming cell can be further considered. In which form and how this is exactly implemented in the cell reselection principles is FFS. |

The rapporteur believes this is a complete list of IDLE mode related agreements taken so far in Rel-17 NTN work. However, please indicate if something has been forgotten.

# 3 NTN indication

First topic to handle in this e-mail thread is whether there is a need to indicate explicitly the network is terrestrial or non-terrestrial. As quoted above in the agreement box, the network type (TN or NTN) should be known to the UE. However, it remains to be seen whether such indication is made in explicit or implicit way. Both approaches had their supporters and fair motivation behind. For instance, [1] states that TN and NTN will anyway likely use separate PLMN IDs (and this option is actually preferred in TR 38.821), so another (explicit) way of differentiating is not needed. In addition, [1] provides another way how this distinction could be done, claiming the NTN cell will likely broadcast NTN-specific system information, while such SI will be absent in the TN cell. In [2] another implicit way of indicating whether the cell is TN or NTN is provided, namely different scrambling of MIB. While this may be a workable solution, the rapporteur thinks it shall be perhaps discussed and decided by RAN WG1. The implicit way of indicating the NW type is also suggested in [3]. One the other hand, a different approach is favoured in [4], where the authors claim the existence of NTN SIB alone may not be sufficient, as TN cells may provide also the neighbour’s SIBs (such as NTN SIB).

Even thought similar questions have been already asked in the past, RAN2 should eventually decide on the type of this indication.

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| **Question 1: How should the UE be made aware of the network type (TN versus NTN)? In implicit or explicit way?** | | |
| **Company** | **Implicit/Explicit** | **Details of how to implement your favoured approach and why the other approach is not viable** |
| APT | Implicit | Implicit by separate PLMN IDs.  If a UE temps to camp on an NTN cell, reading system information in an NTN cell, e.g., PLMN or NTN SIB, shall be sufficient.   * Separate PLMN ID: it was agreed that a separate PLAN is beneficial, e.g., [R2- 1914070] Observation 1: All the companies are in favor to have separate PLMN for the NTN cells from TN cells, but is an implementation choice. Separate PLMN is likely needed. * New NTN SIB: no clear evidence to show NTN SIB is essential, however [R2-2009774] pointed out single satellite’s ephemeris can consume 56 bytes while the NR System Information Block size is constrained to 372 bytes. In this case, NTN SIB is likely needed. * New MIB: no discussion in RAN1 so far. We prefer not to introduce it for the minimum specs impact.   **However, if NW needs to prevent non-NTN capability UEs from camping an NTN cell**, e.g., prevent non-registers from camping or prevent Rel-15/Rel-16 UEs from ignoring NTN SIBs or other NTN information, then a separate PLMN would be the way to go. |
| Ericsson | Implicit as default assumption | As stated, there are multiple implicit ways to indicate this. If, towards the end of the release, RAN2 concludes that none of these implicit ways does not work properly, the explicit option can be further discussed. |
| Lenovo | Implicit | Separate NTN PLMN ID, NTN-specific SIB or the ephemeris can do the work. |
| MediaTek | Implicit as default option | We agree with Ericsson that RAN2 can start with implicit ways and check if it is working. If “not” then explicit ways could be studied. |
| Qualcomm | Implicit | Some indication is needed as it seems likely that CT1 will define new PLMN selection rules for NTN. Use of separate PLMN IDs is problematic as some PLMNs may prefer to use the same PLMN ID for both TN and NTN in order to allow handover and cell reselection within the same PLMN and use a common 5GC.  However, an indication does not necessarily require a flag and could use an NTN specific MIB. This is what is done for LTE MBMS, i.e., MIB-MBMS. An alternative would be to use separate NTN bands.  However, if TN and NTN may use the same band, it will be necessary to prevent SIB1 access from existing TN UEs, which suggests an NTN specific MIB may be a good solution. We should send LS to RAN1 for NTN specific MIB. |
| Turkcell | Implicit as default option | Implicit can be our first option. If implicit option doesn’t work, we will use explicit way. |
| Samsung | Explicit | Spectrum sharing is becoming increasingly common and would result in the same spectrum being used in a TN and an NTN. We also observe that there could be different priorities of NTN Type selection (e.g., HAPS vs. TN and LEOs vs. GEOs) based on the operator preferences. Hence, an explicit indication of the NTN Type is desirable.  The PLMN ID to implicitly indicate the NTN Type is not a reliable solution because the same PLMN ID may use a typical TN spectrum in one geographic area and a typical NTN spectrum in another geographic area.  In our view, the usefulness of the “NTN Type” would increase further if it can also convey the type of the beam (especially to distinguish between Earth-moving beams and quasi-Earth-fixed beams for NGSO satellites). A couple of bits in SIB1 can indicate the platform type (e.g., GEOs, MEOs, LEOs, and HAPS) and the beam type (e.g., Earth-moving cells and quasi-Earth-fixed cells for NGSO satellites). Several companies have expressed interest in Beam Type. Triggers for neighbor cell measurements (and hence cell reselection and handover) would be different based on the type of the beam. So, we suggest combining platform type and beam type in “NTN Type” (“one stone, two birds”!). One of the NTN Types could be TN, or, the absence of NTN Type would imply a TN.  While we prefer 2-3 bits in SIB1, we are also fine exploring the Qualcomm-suggested approach of using a PBCH scrambling sequence to separate a TN from an NTN. Based on the “scope of the NTN Type” (i.e., only TN vs. NTN or a more comprehensive NTN Type that reflects the beam type), RAN2 can convey to RAN1 how many levels of distinction RAN2 prefers. |
| OPPO | Implicit | The presence of NTN specific system information, e.g. satellite ephemeris is sufficient to indicate an NTN cell. |
| Xiaomi | Implicit | Separate PLMN ID, NTN-specific SIB and NTN specific information in SIB can be used for NTN network type indication. |
| CATT | Implicit as default option | Agree with Ericsson. |
| CMCC | Implicit as default | Implicit indication goes first, and explicit solution for FFS. |
| China Telecom | Implicit first | UE can distinguish TN and NTN based on the presence of satellite related information in SIB. We can come back to explicit way when it is necessary to involve this overhead. |
| Spreadtrum | Implicit | Many parameters could be used to indicate NTN cell implicitly: PLMN ID, ephemeris, Koffset, common TA. |
| Huawei, HiSilicon | Explicit | If we go with the implicit solution, we cannot make decisions right now as there is still not enough discussion on the ephemeris or NTN specific SIB.  And if we hope to make it easy in RAN2, an explicit indication is beneficial, e.g. in SIB1, to let UE know this is a NTN cell. |
| Nokia | Implicit | We agree with some of the preceding comments – there are multiple options how to address that in implicit manner. Thus, this shall be attempted, e.g. by using separate PLMN IDs or NTN-specific SIB. |
| LG | Explicit | Related description in TR 38.821 is as following:   |  | | --- | | 7.3.5 PLMN identities deployment  Deployment of PLMNs with specific PLMN IDs for NTN cells and TN cells, or between different type of NTN platforms (GEO or LEO), is considered as a preferred option, however the configuration of common PLMN identities is not precluded. |     As it is still possible that same PLMN can be used between NTN and TN, PLMN deployment cannot be the implicit indication to indicate a cell is TN or NTN.  Another implicit way may be using different frequency band deployment between NTN and TN, as Samsung described. We wonder if NTN and TN shares some frequency band. So we think explicit indication should be used to indicate TN or NTN cell. |
| Intel | explicit | It is a much simply UE implementation without needing to figure out if it is TN or NTN network. |
| BT | Neutral | We consider PLMN ID is not a valid parameter to differentiate among TN and NTN. |
| Sony | Implicit | We are ok to have this as the default assumption and revisit later |

A somewhat related topic concerns another indication type – the specific NTN scenario (such as GEO, LEO, HAPS, etc.). It has been argued that also the specific LEO/GEO/HAPS scenario could be inferred from some typical values of the configuration parameters [1][2], so there is no need to signal such information separately. [5] proposes that satellite type (GEO vs. non-GEO) is determined implicitly, based on ephemeris data representation. On the other hand, [4] claims such NTN scenario type (e.g. LEO or GEO) is indicated along with the network type (TN or NTN).

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| **Question 2: Do you see the need to signal explicitly the NTN scenario information (e.g. LEO/GEO)? Please motivate your answer.** | | |
| **Company** | **Yes/No** | **Motivation** |
| APT | No | If UE temps to camp an NTN cell, ephemeris data for the target satellite would be needed for sending a PRACH preamble. |
| Ericsson | No as default assumption | Similar to the first question, there are multiple implicit ways to indicate this. If, towards the end of the release, RAN2 concludes that none of these implicit ways does not work properly, the explicit option can be further discussed. |
| Lenovo | Implicit | The ephemeris can do the work. |
| MediaTek | No as default | The position information or ephemeris can be used to determine this. |
| Qualcomm | No as default | This can be implicit from broadcast parameters. However, we agree that an explicit indication is needed if an implicit solution is not agreed. |
| Turkcell | No as default | As we answer in Question 1, NTN scenario information can be signalled implicitly. |
| Samsung | Yes | We prefer to have an explicit NTN Type that also reflects the type of the platform (e.g., HAPS vs. LEO vs. GEO) and the beam type (especially Earth-moving and quasi-Earth-fixed). Such information may be conveyed in SIB1 or a PBCH scrambling sequence. This will avoid the need for the UE to avoid unnecessary processing of an NTN SIB that carries the ephemeris information. For example, on a given carrier frequency, if a certain network type (e.g., an NTN or a TN) is preferred (i.e., prioritized), the UE can quickly learn about the NTN type and move on to a different carrier frequency instead of wasting time and processing power decoding the NTN SIB (and possibly other SIBs before it can process such NTN SIB) containing the ephemeris data. In summary, an explicit and compact (i.e., a couple of bits) indication of the NTN Type would help the UE save processing power and quickly determine a suitable cell. |
| OPPO | No | UE could derive GEO vs. LEO based on satellite ephemeris information.  For LEO scenario, an indication of earth moving beam or earth fixed beam is needed for mobility management, e.g. cell (re)selection. |
| Xiaomi | No | The ephemeris can be used for NTN scenario indication. |
| CATT | No as default assumption | The ephemeris can implicitly indicate this. |
| CMCC | No | The satellite ephemeris is enough to deduce NTN scenario type. |
| China Telecom | No | Ephemeris provides more detailed information. |
| Spreadtrum | No | The ephemeris can indicate it. |
| Huawei, HiSilicon | Yes | Same comments as for Q1. If we depends on implicit solution, we have to wait for the progress on other topics. If we need to make decision now, an explicit solution is a good way to go. |
| Nokia | No | It is not yet known what exactly the ephemeris will contain and how the UE would use it to calculate and interpret its contents. However, we assume that for the UE to be NTN-capable, it would have to comprehend the contents of ephemeris and on their basis, be aware what scenario these values represent. |
| LG | See comments | Rather than just indicating LEO and GEO, we think beam type of LEO satellite should be indicated, i.e. earth-moving beam & earth-fixed beam. As moving beam coverage changes dynamically, the measured cell quality may decrease rapidly. Therefore, even if measured cell quality with moving beam is higher than a cell with moving beam, it may be better for the UE to reselect the fixed beam cell because cell quality of fixed beam will be stable until the beam steers to the next serving area on the ground. So we think some different scheme of UE mobility criteria may be needed for LEO satellites. How to differentiate the UE mobility can be further discussed. If beam type of LEO satellite is provided in the ephemeris information, it implicitly indicates whether an NTN cell is LEO or GEO. |
| Intel | No | We agree such information can be derived from the ephemeris. However, in case later the solution doesn’t seem to be able to derived such information, we can revisit this topic. |
| BT | Neutral |  |
| Sony | No | We are ok to revisit during stage-3 |

If implicit way of indicating the NTN scenario is preferred, please provide the details how this shall be done. In the papers submitted to RAN2-112 various approaches have been presented (see e.g. [1][2][5]).

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| **Question 3: How to provide the NTN scenario indication using implicit means?** | |
| **Company** | **Answer** |
| APT | Implied from the common parameters provided in SIB, e.g., ephemeris data. |
| Ericsson | Implied from parameters giving the characteristics of the system, e.g. ephemeris. |
| Lenovo | By parameters provided in the ephemeris e.g. orbit. |
| MediaTek | The position information or ephemeris can be used to determine this. |
| Qualcomm | Yes from parameters broadcast in SIB1. |
| Turkcell | Implied from the common parameters, e.g. ephemeris data |
| Samsung | In case the implicit method is chosen (e.g., a PBCH scrambling sequence), the scrambling sequence number would indicate the NTN Type that defines the type of the NTN platform (e.g., GEO, non-GEOs, and HAPS) and the beam type. |
| OPPO | Derive GEO vs. LEO from satellite ephemeris information. |
| Xiaomi | The Orbital parameters or Satellite coordinates in the ephemeris can be used for NTN scenario indication. |
| CATT | The ephemeris can implicitly indicate this. |
| CMCC | Please see our comments to Q2. |
| China Telecom | From satellite related parameters such as ephemeris. |
| Spreadtrum | The ephemeris can indicate it. |
| Huawei, HiSilicon | If ephemeris data is preferred, it should be provided in SIB1 to lower the latency of access. |
| Nokia | Either from the ephemeris or based on some other, scenario-specific parameters (such as Koffset). |
| Intel | We prefer using ephemeris data. |
| Sony | It may be derived from ephemeris data and/or implementation-based aspects like received signal strength and frequency band etc. |

# 4 Ephemeris

Another important topic that shall be addressed in RAN2 during NTN Rel-17 WI is how to provide the UEs with satellite ephemeris information and what is should contain. As argued in [1] the satellite ephemeris could have an excessive size, quickly overloading the capacity offered by System Information Block (SIB) in NR. Before deciding how to deliver the satellite ephemeris to the UE, it shall be discussed how the ephemeris is actually represented. Two main approaches have been identified and captured during the NTN SI in Rel-16:

* Orbital parameters (including orbital and satellite related parameters)
* Satellite coordinates, e.g. ECEF coordinates to represent satellite’s position (x, y, z), time, velocity, etc.

As usual, both options have pros and cons. The orbital parameters are better in terms of their size and signalling overhead, while the ECEF representation may provide increased accuracy, but at the expense of the need to update them frequently [6].

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| **Question 4: How should the ephemeris be represented (e.g. PVT coordinates or orbital plane parameters)?** | |
| **Company** | **Answer** |
| APT | PVT (ECEF representation) to support HAPS/HIBS.  Only instant orbital state vector format has the ability for implicit compatibility to support HAPS/HIBS and ATG scenarios since the orbit concept is meaningless in HAPS/HIBS and ATG scenarios.  As a price, enhancement on signaling overhead can be FFS, e.g., update more frequently on satellite’s position (x, y, z) and time, but update less frequently on satellite’s velocity. Also, enhancement on RRM can be FFS, e.g., orbital parameters can be pre-stored in u-sim as assistant information to predict long-term satellites’ positions. |
| Ericsson | First aspect to know is what is the precision needed. The maximum allowed error of the TA, while preserving OFDM/OFDMA orthogonality, is determined by the length of the cyclic prefix (CP). Besides TA error, the CP also absorbs other effects such as multipath delay spread to preserve OFDM/OFDMA orthogonality. In 5G NR, the length of the CP is not fixed, but depends on the subcarrier spacing (SCS). For FR1, SCS of 15 kHz and 30 kHz are allowed, resulting in CP lengths of 4.69 µs and 2.34 µs, corresponding to a distance of 1.4 km and 700 m, respectively. Since the TA handles RTT, however, these distances have to be divided by 4 for the transparent case. In the worst case (transparent architecture and 30 kHz SCS), the CP length of 2.34 µs would thus allow the satellite to be 175 m away from its nominal position, where the UE expects it to be. As this is very much a RAN1 topic, the discussion about ephemeris data format and accuracy requirement should start in RAN1.  While the information content of all possible formulations might be equivalent, the amount of data needed to encode the information varies. The choice of format should strive to minimize the amount of data that needs to be transmitted or stored in the UE, e.g. by choosing a convenient coordinate system. |
| Lenovo | Both can be considered for different platforms or purposes, e.g. orbital parameters for satellites and ECEF coordinates for HAPS. For either option we need to consider minimizing the amount of ephemeris data and avoid too frequent provision, e.g. ephemeris data of a group of satellites on the same orbit can be represented as the common part (e.g. orbit plane) that can be pre-provisioned and individual part (e.g. anomaly or difference of satellite level parameters) that can be broadcasted/signalled. |
| MediaTek | For initial access and uplink synchronization, where high precision is required, PV information is appropriate. For cases with low precision, e.g. long-term ephemeris for mobility, either options (i.e. PV or orbital parameters) can be used.  Note: RAN1 is also discussing this topic with relation to initial access and uplink synchronization. |
| Qualcomm | We also think RAN1 is discussing this topic and we can wait for RAN1 progress. |
| Turkcell | We can wait RAN1 progress in initial access and uplink synchronization. |
| Samsung | Let’s wait for RAN1’s progress. |
| OPPO | Since the two options may provide different accuracy, which option to be adopted depends on the accuracy requirement. We could wait for RAN1 progress. |
| Xiaomi | Satellite coordinates can be used to support GEO and HAPS. Orbital parameters can be used to support LEO and MEO. |
| CATT | The ephemeris format will be determined by the required accuracy, signalling overhead and application scenarios.  Using Orbital parameters would help UE to derive satellite position in a long time. This is very useful for UE to conduct initial satellite search in the initial access stage if UE is awake after long time sleep. But the typical drawbacks of orbital parameters based ephemeris may include signalling overhead, rough accuracy and high computation complexity. Actually if with more frequent broadcasting for orbit parameters, the derived satellite position is accurate enough.  Using PVT ephemeris may need frequent broadcasting, though it owns high accuracy in one moment. For LEO case, the PVT information aging is worse compared to orbital parameters. From technical point of view, orbital parameter based ephemeris type is equivalent with PVT based ephemeris. The essential difference is just relying on which side to make final position calculation.  Depending on application scenarios, the combination of two types of ephemeris information can be considered. For example, in the initial access stage, orbital parameter is more effective, but in the RRC connected mode, PVT information is much simpler to reduce UE computation complexity. |
| CMCC | From our perspective, the factor of compatibility to support both HAPS and ATG need to be taken into account. Since only instant orbital state vector format can meet this requirement, we prefer this one. Additionally, as the discussion on this issue is ongoing in RAN1, we should be on the same page. |
| China Telecom | We think two options should be supported for different use cases.  Orbital parameters are a long term information for UE to extrapolate the trace of satellites. UE can predict which satellite will be suitable to camp on. It is useful for NTN based cell selection/reselection strategy. Satellite coordinations provide the exact position of satellites. For the purpose of time and frequency compensation, UE needs to know the current information of satellites. But the information maintains valid for a short term, the update overhead is higher.  Thus, we suggest to use orbit parameters as long term information for cell selection/reselection strategy while use location of satellite in coordinates as short term information for time and frequency compensation. |
| Spreadtrum | The orbital parameters could provide the satellite position in a long duration at the cost of higher overhead. Considering the orbital information shall not be updated frequently, we prefer orbital parameters. |
| Huawei, HiSilicon | The accuracy requirement should be met no matter which option is adopted finally. With the same accuracy, the differences between these two solutions can be signalling overhead, i.e. message size and updating frequency. From this perspective, we need to wait for RAN1 input before we make a decision.  In our understanding, at least with orbital parameters it would be beneficial to perform initial cell selection, because UE can know the coarse orbit information to adjust its beam direction. |
| Nokia | We are OK to postpone the ultimate decisions until RAN1 makes some progress regarding the initial access, synchronization and what kind of content is needed for such purpose in the ephemeris. We acknowledge that if Rel-17 NTN shall also support HAPS then satellite orbit concept (orbital plane parameters) may not be useful. However, we are concerned about potential signalling impact the PVT representation may bring, if it has to be sent too often. |
| LG | We also think it is not really RAN2 issue and we can wait for RAN1 input. |
| Intel | Agree with companies that we should wait for RAN1 |
| Sony | We are ok to postpone and wait for RAN1 input regarding accuracy requirements but RAN2 needs to discuss the size and how to broadcast this information. |

After selecting how to represent the NTN ephemeris, it is worth checking the details, i.e. what it shall actually contain, (e.g. what parameters and how many bits those would consume, etc.). Please share your view to the following question.

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| **Question 5: What information and parameters should be conveyed in the NTN ephemeris? Please indicate on the content, bit consumption and the required periodicity of broadcasting such information.** | |
| **Company** | **Answer** |
| APT | Satellite position and velocity.  Based on [R1-2008809] given sufficient accuracy on UL time and frequency pre-compensation, e.g., error ranges for satellite position and velocity are ∆U < ±120m and   * Parameters: Satellite position {X, Y, Z} and satellite velocity {Xvel, Yvel, Zvel} * Bit consumption: 18 Bytes (144 bits) * Required periodicity: 1 second.   [R1-2008809] Assuming serving satellite ephemeris is broadcast every second. The payload on NTN SIB to indicate serving satellite cell position and velocity is (84+60)/8 = 18 Bytes   |  |  |  |  | | --- | --- | --- | --- | | Information | Range | Resolution | #bits | | Satellite Location | ±43000 km | 0.33m | 3\*28=84 | | Satellite Velocity | ±8 km/s | 0.015 m/s | 3\*20=60 | |
| Ericsson | We actually think it is the other way around. RAN2 should study(should have studied in SI phase..) the practical difference between these format options and the ways to represent the needed data in most efficient way enabling the accuracy that is needed(RAN1 work).  Another aspect discussed during the study item and captured in TR 38.821, is the validity time of ephemeris data. Predictions of satellite positions in general degrade with increasing age of the ephemeris data used, due to atmospheric drag, maneuvering of the satellite, imperfections in the orbital models used, etc. Therefore, the publicly available TLE data are updated quite frequently, for example. The update frequency depends on the satellite and its orbit and ranges from weekly to multiple times a day for satellites on very low orbits which are exposed to strong atmospheric drag and need to perform correctional maneuvers often. |
| Lenovo | The ephemeris of neighboring satellites or a group of satellites on the same orbit, which can help in mobility management and reduce signalling/broadcast overhead. |
| MediaTek | For the serving cell to meet the high precision requirements for uplink synchronization, satellite position and velocity (PV) information are required and needs to be updated frequently. For mobility purposes we can use either PV information or orbital plane parameters, and these parameters do not need to be updated frequently as high precision is not required. |
| Qualcomm | The ephemeris should probably be related to UTC/GNSS time which would be available to a GNSS capable UE and enable prediction of future satellite location for the duration of satellite visibility to a UE. The exact format can be left to RAN1 based on required accuracy needed. |
| Turkcell | Similar to Question 4. |
| Samsung | RAN1 and RAN2 should identify the parameters that are needed for both methods for various purposes (e.g., for timing and frequency compensation and cell reselection/handover measurements) and determine the required periodicities to meet target accuracies.  From RAN2 perspective, to represent the ephemeris information, we suggest separation of short-term information (i.e., the information that changes rapidly such as the satellite position (Px, Py, Pz)) and long-term information so that different NTN SIBs can carry such information with different periodicities and reliabilities (e.g., repetition of information in successive TTIs). Furthermore, to represent the information fewest possible bits, different numbers of bits can be used to represent different parameters (e.g., X bits for the position and Y bits for the velocity) based on sensitivity or accuracy requirements and expected parameter ranges. In current networks, RSRP values are reported using a formula. Such approach can potentially be considered to obtain a target accuracy for a given parameter to minimize the number of bits. Example formula: TV = α\*IV+β, where TV is the True Value of the quantity and IV is the Indicated Value specified in a SIB. Another possibility is to use incremental values instead of absolute values after defining reference values in a SIB or specifications. |
| OPPO | The content and the update periodicity of ephemeris depends on the accuracy requirement. We could wait for RAN1 progress. |
| Xiaomi | Satellite position, velocity and orbital parameters should be included in ephemeris. |
| CATT | RAN2 work is to identity the use case and required accuracy of ephemeris. Detailed comparison between accuracy and overhead should be left to RAN1. |
| CMCC | The ephemeris of serving satellite (e.g. satellite position and velocity (PV) information) is necessary at least. And the ephemeris of some neighbour satellites is also required for mobility decision purpose. |
| China Telecom | Position and velocity is necessary. For LEO, indicating the earth fixed beam or moving beam is useful for mobility. |
| Spreadtrum | Orbital parameters, satellite position in the orbital, and velocity shall be included. In addition, the ephemeris of coming satellites shall be provided for mobility procedure. |
| Huawei, HiSilicon | It depends on RAN1 to provide the information on message size and updating frequency. In RAN2 we can consider the ephemeris format in TR 38.821 as a staring point. |
| Nokia | We agree that at least the data for calculating or obtaining directly the serving cell’s satellite position and velocity in time is needed. Some details on how many bits it may consume were shown in our paper [1]. Also, the calculations shown above by APT look fine. We are OK not to speculate about a bit consumption needs before RAN1 concludes on the required accuracy. |
| LG | Moving path of each LEO satellite should be informed. Based on the assumption that the network is aware of location information of each UE, expected visible NTN cell information from the UE location should be informed. The NTN cell information may include not only current NTN cell list but also upcoming NTN cell list, so that the network does not need to update the information frequently. |
| Intel | We think that at least satellite position, velocity and path information. |
| Sony | Agree with Intel |

In [7] it is argued there is a need to provide the UE with the ephemeris for both the camped/serving cell and the neighbours. As per [7] the ephemeris for the neighbours is necessary for the UE to re-adjust the pointing direction towards the neighbouring satellite before performing inter-satellite HO or inter-satellite cell reselection. The camped/serving cell’s ephemeris is claimed to be necessary for maintaining the UL timing and frequency synchronization [7]. It also seems to be important to know whether the cell belongs to the same satellite, in order to avoid potential signalling overhead. Do companies see a need to have a split and provide camped/serving cell’s and neighbour’s ephemeris plus the information on any other association of the cell?

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| **Question 6: Should the ephemeris be divided into camped normally cell’s and neighbour’s part? Is the information on any other association of the cell needed? Please motivate your answer.** | | |
| **Company** | **Yes/No** | **Motivation** |
| APT | No | Yes, the ephemeris for the target cell is necessary.  No, the association of a neighboring cell is not necessary. It can be associated with RA configuration.  For random-access (RA), UE needs valid/updated ephemeris data to calculate UL timing and frequency for PRACH preambles. If ephemeris data is only used for RA, then it may only be associated with RA configuration. |
| Ericsson | Most likely yes | We should start by defining the camped normally cell’s emphemeris and see then what is needed about neighbour cells/satellites. |
| Lenovo | Yes | See answer in Question 5, at least ephemeris of neighboring satellites can help in mobility management and reduce signalling/broadcast overhead. |
| MediaTek | Yes | We definitely require high precision ephemeris information for the serving cell for uplink synchronization. The level of details required for the neighbour cells can be investigated further. Details are mentioned in our response to Question 5. |
| Qualcomm | Yes | It is better to have information of neighbour cells for idle mode mobility and RRM and handover support in connected mode. We may need to wait for RAN1 progress on the details. |
| Turkcell | Yes | Camped normally cell’s ephemeris and neighbour’s one can be used depends on the scenarios. As we answer in Question 5 and Question 4, we need to wait RAN1 progress. And we firstly need to define camped normally cell’s ephemeris. |
| Samsung | Yes | It would be better to have info about the ephemeris of the serving cell and neighbor cells. To reduce signaling overhead, only distinct satellite ephemeris data are included instead of replicating the same satellite ephemeris for multiple cells. For example, if multiple cells belong to the same satellite, the ephemeris data for the satellite is not repeated for all these cells. |
| OPPO | Yes | The ephemeris information of serving cell is needed for uplink synchronization, and the ephemeris information of neighbour cells may be useful for mobility management. |
| Xiaomi | Yes | The required ephemeris for the neighbour cells may be different from the serving cell, so the further study is necessary. |
| CATT | Yes | Both ephemeris data of serving cell and neighbour cell are useful from the perspective of RAN2. |
| CMCC | Yes | Ephemeris of neighbour satellite is important to solve the mobility issues for both idle mode and connected mode, as expressed in Question 5. |
| China Telecom | Yes | It helps for UE to find the target satellite faster. |
| Spreadtrum | Yes | The ephemeris information of neighbour cells are helpful for mobility. In addition, the information of position relationship of the neighbour cell under same satellite should be provided too. |
| Huawei, HiSilicon | Yes | At least different accuracy requirements are for camped cell and neighbour cells. In camped cell UE needs to perform uplink synchronization in case of data transmission, but for neighbour UE only needs to perform downlink measurement. |
| Nokia | Yes | Agree with MTK, serving/camped cell’s ephemeris is especially needed, e.g. for uplink synchronization. Thus, in order to save on signalling, we think it is desired to have a different approach to neighbours and serving cell’s ephemeris. |
| LG | Yes | Please see our answer in question 5. As NTN cell has very large coverage size so that each UE in an NTN cell may see different NTN cell list. So next NTN cells which will appear to the ground can be provided to the UEs so that the information does not need to be updated at every LEO appearance. |
| Intel | Yes | Both serving and neighbour cell information are useful to reduce UE power consumption and measurement. |
| Sony | Yes | Both serving and neighbour cell information are useful and could potentially be in different SIBs. |

Besides the format and split of ephemeris, it needs to be discussed and decided how this information is provided to the UE. As argued in [1], the size of ephemeris can be extensive, if orbital plane parameters and satellite parameters are signalled, these can consume 56 bytes for a single satellite (including its orbital related parameters), while the allowable size of NR SIB is 372 bytes. It can be easily noticed the entire SIB’s capacity can be exhausted by the ephemeris for just several satellites. Thus, e.g. [7] discusses other means to provide the UE with the ephemeris, such as storing constellation ephemeris in the uSIM or in the UE. This is expected to work if the network is able to send periodical updates to such static ephemeris, kept at the UE. As a reference, in case of GPS, the almanac is updated every 12.5 minutes while the ephemeris can be updated within 30 s. Companies are asked to provide their views in this area.

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| **Question 7: How should the ephemeris be provided to the UE (e.g. pre-provisioning via uSIM, SIB, and other aspects like how to divide into a static and dynamic part, if necessary)?** | |
| **Company** | **Answer** |
| APT | New NTN SIBs to support the PVT (ECEF representation). |
| Ericsson | Pre-provision, NAS, RRC(SI or dedicated) should all be considered. Further different ways to quantize the data needs to be considered. Some examples, orbital info can be given as orbital planes/sub planes and SI can point with index to orbital sub plane. Division can be in time, given sparsely finer data and more frequently updates. |
|  | Pre-provisioning, SIB and RRC can be considered at this stage. For either option we need to consider minimizing the amount of ephemeris data and avoid too frequent provision, e.g. ephemeris data of a group of satellites on the same orbit can be represented as the common part (e.g. orbit plane) that can be pre-provisioned and individual part (e.g. anomaly or difference of satellite level parameters) that can be broadcasted/signalled. |
| MediaTek | For the serving cell, we definitely need it to be provided in the SIB, as it will be updated frequently. For neighbour cells, a mix of pre-provisioned and broadcast information could be used. |
| Qualcomm | Pre-provisioning in uSIM does not need to be excluded. A new SIB can be considered to provide ephemeris for UEs in IDLE state. For UEs in CONNECTED state, unicast message by the serving gNB can be used. |
| Turkcell | We can use SIBs. Static part can be signalled with less frequent SIB. Pre-provisioning can also be considered. |
| Samsung | Identify the type of information needed by the UE. Then, separate out long-term information and short-term information. Certain long-term information can be conveyed to the UE via pre-provisioning or through application-layer signaling via cellular access or WiFi access to avoid the use of precious NTN radio resources. A valueFlag in a SIB can point to the latest version of long-term data so that the UE can receive any update via an NTN or a TN. |
| OPPO | If the ephemeris is presented in forms of orbital parameters, orbital related parameters could be pre-provied via uSIM, while satellite related parameters for serving cell and neighbouring cells could be provided via SIB.  If the ephemeris is presented in forms of satellite coordinates, it should be provided via SIB since the ephemeris needs to be update frequently. |
| Xiaomi | We think SIB can be considered to provide ephemeris to UE. |
| CATT | It had better classify the ephemeris data into static and dynamic part. The static part can be pre-configured, and the dynamic part can be provided in SIB or RRC.  Depending on the ephemeris type applied, in general pre-provisioning, SIB and RRC dedicated signalling can considered together for sake of overhead reduction. |
| CMCC | The listed candidates need to be considered for different cases, in order to pursue the minimization of the amount of ephemeris data and reduction of frequent provision. For example, static part which does not need to be updated in real time could be pre-provisioned in uSIM, while dynamic part could be updated timely via SIB or RRC signalling. |
| China Telecom | Pre-provision for static parameters and SIB for dynamic parameters. |
| Spreadtrum | A new SIB shall be introduced. If PVT ephemeris is agreed for question 4, this new SIB shall support frequent updating mechanism.  In addition to SIB, pre-provided mechanism with periodic update can be considered for big amount of ephemeris data. |
| Huawei, HiSilicon | If PVT format is adopted, it can be broadcasted in SIB. And if orbital parameters are adopted, pre-provision can be considered. |
| Nokia | We agree that a mixture of different means is needed to provide and update the ephemeris in various scenarios. NAS, SIB and pre-provisioning shall be thoroughly considered when we know the exact contents (i.e. the number of bits required) and the required periodicity (i.e. the required accuracy). Of course, not all of these (SIB, NAS, pre-config) are necessarily needed/available in each of the scenarios (e.g. initial access). |
| LG | How much information can be included in uSIM is not clear yet, so we do not need to preclude the case. We think dedicated signalling may be better than broadcast way, because each UE in an NTN cell may see different LEO satellites because of large NTN cell coverage. |
| Intel | We think that SIB should be used at least for serving cell. Neigbouring cells information can be sent via pre-provision. |
| Sony | We think a combination of pre-provisioning and SIB/NAS is a good way forward |

# 5 Cell reselection

As stated in section 2, the NR cell reselection framework, including the existing cell reselection priority configuration, is taken as a baseline for NTN. However, at RAN2#112 further decisions have been made: the information concerning when a cell is going to stop serving the area and information about new upcoming cell can be further considered. However, the exact form and its use in cell reselection process is FFS. Here we attempt to discuss more details of this information, also considering that this has been already partially done in [8] and in the e-mail discussion preceding RAN2#112.

In [8] there were different views expressed how this additional information can be expressed:

* A list of neighbour cells, provided in the system information
* Ephemeris and resulting calculations done by the UE (i.e. no additional separate information provided/broadcasted)
* Separate broadcasting of time left in the camped/serving cell or time until a new cell becomes available

If any other means were considered and are missing in the list above, please indicate in the table below, for Question 8. Companies are kindly asked to first answer if this additional information on ’when a cell is going to stop serving the area and information about new upcoming cell’ should be a mandatory part of the cell reselection for NTN. Current agreement states this information ‘can be further considered’, which does not seem to be binding in any way.

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| **Question 8: Should the additional information on when a cell is going to stop serving the area and information about new upcoming cell become a mandatory part of the cell reselection in NR? Please motivate the answer, especially if you think legacy reselection is not sufficient (please state why).** | | |
| **Company** | **Yes/No** | **Motivation** |
| APT | No | The dwell time is good to have, but not essential to us. |
| Ericsson | Yes | This is a network planning outcome and there is no other way for the UE to know when cell is about to leave and new is coming. Especially for soft feeder/service link switch, there is no point to have all IDLE mode UEs wait for the camped normally cell to actually vanish in order to trigger cell reselection. |
| Lenovo | No | The information is not mandatory as an NTN cell ceasing to serve will trigger neighboring cell measurement for the UE (legacy can work). Meanwhile other enhancement like time/location-based cell reselection can also solve the issue so the information can be optional. |
| MediaTek | No | As a baseline we can rely on the measurement mechanisms. When the serving cell leaves and a neighbour cell covers an area RSRP/RSRQ measurements could be used for cell reselection. It could be useful to have information about when an upcoming cell will serve the area, e.g. if there is any impending coverage-hole. |
| Qualcomm | Yes | If the cell is going to be switched off, cell expiry time is needed. Additionally, information on next serving cell(s) is very useful. |
| Turkcell | Yes | RSRP/RSRQ triggering in TN can’t be worked especially for satellites far from UEs. The center of cell and edge of the cell have similar values of measurement. |
| Samsung | No | Different strategies are needed and are suitable for different types of beams. Please see our response to Q9 below. |
| OPPO | No | We think we should focus on the scenario of feeder link switch firstly since we have not discussed to use this additional information for service link switch by now.  When feeder link switch happens, UE would detect the cell stopping serving the area based on measurement, so the information about when a cell is going to stop serving the area is not necessary, and how to search and camp on a new cell is up to UE implementation, so the information about new upcoming cell is also not needed. |
| Xiaomi | No | As a baseline, the legacy cell reselection mechanism of NR can be reused for NTN. Moreover, we think the dwell time of serving cell can be only used for the case which the cell reselection is caused by feeder link switch. |
| CATT | No | This information is not mandatory. Cell reselection based on UE location and the ephemeris data can also achieve the same effect. |
| CMCC | No | Even though the dwell time is helpful, it is not mandatory. If the signal of serving cell becomes worse, measurement will be triggered. |
| China Telecom | No | It can assist cell reselection process but it is not mandatory. |
| Spreadtrum | No | UE could determine the serving cell based on UE location and ephemeris parameters. If the feeder link modification is indicated to UE in advance, UE may determine the coming cell more quickly. |
| Huawei, HiSilicon | No | This is an enhancement for cell reselection, the UE can work even without it. |
| Nokia | Yes | We think it could be helpful, at least in some scenarios, e.g. for Earth-fixed cells in sparse deployments or when frequency is reused, etc. |
| LG | Yes | We think allowed time to access to or camp on the NTN cell can be considered, because especially LEO satellites are visible to ground UEs during only particular time period, which is 15~20 minutes. Though measured cell quality is still important parameter to consider, but only cell quality condition is not enough. For example, if a measured cell quality is good but the cell will disappear soon, the UE would better not to reselect the cell because it should reselect another cell soon again.  Therefore, we think time condition can be considered together with existing cell quality condition. |
| Intel | No | We think that it will be helpful to get future serving information. However, we should use the basic approach for the first release and think of enhancement in later release. |
| BT | Yes | Legacy TN mechanisms based on RSRP/RSRQ won’t work for NTN therefore, a new procedure is required. It is important to notice that for non-fixed beams on Earth, it’s difficult to conclude a common remaining time per beam. Therefore, the last proposed bullet seems difficult  If the neighbour list plays a key role, it is required a mechanism that guarantee the information is valid all the time. |
| Sony | Yes | UE should be able to calculate the remaining time when the serving cell will disappear and should not go through the cell reselection criteria evaluation every time the cell disappears. |

In case you have answered ‘Yes’ to Question 8 (or have other insights in this area), please provide further details in what form is this information provided and how it is employed in the NTN cell reselection procedure. Please describe how the potential solution differs between Earth-moving and Earth-fixed scenario.

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| **Question 9: In what form and how is this additional information employed in NTN’s cell reselection process? Please underline the differences between Earth-moving and Earth-fixed scenario.** | |
| **Company** | **Answer** |
| Ericsson | Especially for soft feeder/service link switch, there is no point to have all IDLE mode UEs wait for the camped normally cell to actually vanish in order to trigger cell reselection.  The exact form can be e.g. time stamp associated with PCI. Other forms can be discussed as well. This is needed for service/feeder link switch for Earth fixed cells and feeder link switch for Earth moving cells. |
| MediaTek | During initial NTN deployment it is not expected to have full coverage at all time. It could be useful to have information about when an upcoming cell will serve the area, e.g. if there is any impending coverage-hole. |
| Qualcomm | Simply, SIB1 can broadcast expiry time of current cell and next cell ID(s) to cover the area. |
| Samsung | Different strategies are needed for different types of beams (i.e., Earth-fixed, quasi-Earth-fixed, and moving-Earth beams). We suggest the following.  A. Support flexible combination triggers for cell reselection similar to what RAN2 has discussed for handover (e.g., RSRP and time/timer, RSRP and distance, and so on), because pure RSRP/RSRQ-based cell reselection is not adequate for an NTN. Some combinations (e.g., the ones using a timer) would be suitable for quasi-Earth-fixed beams and Earth-moving beams but not for fixed-Earth beams. Consider SIB-based cell change for quasi-Earth-fixed beams.  B. Enhance neighbor search mechanisms in idle, inactive, and connected modes to save UE power and avoid potential throughput loss associated with SMTC by defining an  inner area of the cell where neighbor cell measurements are not needed. A pure RSRP-based criterion used in a TN would not be adequate for an NTN (just like a combination trigger would be more reliable in an NTN compared to a pure RSRP-based trigger for cell reselection and handover).  C. Enhance the neighbor list by exploiting predictable satellite movements by encouraging cell reselection to incoming cells (e.g., via a movement-based offset) and preventing cell reselection to outgoing cells through a blacklist/whitelist or a timer.  D. Explicitly indicate “Beam Type” (i.e., Earth-fixed, quasi-Earth-fixed, and moving-Earth beams) to facilitate measurements and evaluation of suitable trigger conditions.  E. Management of Tracking Areas (TAs). RAN2 has agreed to have fixed-Earth TAs. However, the way to realize fixed-Earth TAs in practice has not yet been formally discussed in RAN2. We have a serious concern with the approach where the cell transmits multiple TAIs. If a cell transmits multiple TAIs, there would often be a need to change TAIs in the middle of a SIB transmission, adversely affecting reliability of SIB detection. Furthermore, there would be a risk of cell-border UEs missing a SIB if such SIB does not reflect the overlap among the cells or TAIs. We suggest that RAN2 consider alternatives such as time-based mapping between fixed-Earth TAs (“Virtual Tracking Areas”) and traditional R16-like TAIs known to both UE and AMF, where a cell broadcasts only one TAI. The UE compares the TAI broadcast by the cell and the mapping between the VTA and TAIs to determine if it needs to do registration/TA update or not. Predictable satellite movements and fixed relative locations of NTN cells make the time-based mapping feasible. The VTA-TAI mapping can be conveyed to the UE via application-layer signaling, avoiding consumption of NTN radio resources. |
| Huawei, HiSilicon | Considering the NTN cell is quite large, we think it’s necessary to provide this information in smaller granularity, i.e. for UEs in different positions within one NTN cell different timing information should be provided. |
| Nokia | This can be known from the radio measurements (cell detection and its signal quality) + the ephemeris content. For the cases where the mechanism from Q9 is applicable, this may be provided in SI or RRC Release message. |
| LG | As we stated in question 5 & 6, next cell list information can be considered. The information may include list of cells and when each cell will appear to a specific ground location. |
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Somewhat different aspect, still related to cell reselection in NTN, was discussed in [1], namely the number of reselection priorities. It was observed that up to 40 different priorities can be provided, thanks to the existence of up to 8 different values of *cellReselectionPriority* and up to 5 different values of *cellReselectionSubPriority*. Companies are invited to comment whether such reselection means are sufficient.

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| **Question 10: Is the existing NR cell reselection prioritization, in terms of the number of different priorities that maybe configured, sufficient for NTN?** | | |
| **Company** | **Yes/No** | **Motivation** |
| APT | Yes | The reselection means based on RSRP/RSRQ measurement shall be the baseline. |
| Ericsson |  | Would start discussing how the cell selection/reselection needs to work and then see if more priorities are needed. |
| APT | Yes | The existing NR cell reselection prioritization shall be the baseline. |
| MediaTek | Yes | Priority mechanism is the baseline for inter-frequency reselection, as in Rel. 16. |
| Qualcomm | Yes | Existing mechanism should work. |
| Turkcell |  | The existing NR cell reselection prioritization can be our baseline. But we haven’t decided how the cell reselection works in NTN. We don’t have strong views on its prioritization. |
| Samsung | Yes | The existing mechanism seems to be sufficient for an NTN. |
| OPPO | Yes | The existing NR cell reselection prioritization shall be the baseline. |
| Xiaomi | Yes | The existing NR priority mechanism shall be the baseline. |
| CATT | Yes |  |
| CMCC | Yes | Legacy mechanism could be the baseline. |
| China Telecom | Yes | China Telecom |
| Spreadtrum | Yes | The existing mechanism shall be baseline. |
| Huawei, HiSilicon | Yes |  |
| Nokia | Yes | The existing cell reselection parameters and their ranges are sufficient in our opinion. However, we can try not to make any Stage-3-like decisions at this time. |
| LG | Yes | Current mechanism is enough. |
| Intel | Yes |  |
| BT | No | First, we need to conclude on the cell reselection mechanisms started in Q9. After that, we should be able to move forward.  With *CellReselectionPriority* and *CellReselectionSubPriority* it is possible to prioritize the frequency but as we consider RSRP/RSRQ is not enough, both parameters are not sufficient when inter-frequency reselection is required.  The IE *CellReselectionPriority* concerns the absolute priority of the concerned carrier frequency, as used by the cell reselection procedure. Corresponds to parameter "priority" in TS 38.304 [20]. Value 0 means lowest priority. The UE behaviour for the case the field is absent, if applicable, is specified in TS 38.304 [20].  The IE *CellReselectionSubPriority* indicates a fractional value to be added to the value of *cellReselectionPriority* to obtain the absolute priority of the concerned carrier frequency for E-UTRA and NR. Value *oDot2* corresponds to 0.2, value *oDot4* corresponds to 0.4 and so on. |
| Sony | Yes | We think it is a good starting point. |

# 6 Conclusions

Based on the views expressed in the previous sections, we propose the following:

# 7 List of referenced documents

[1] R2-2009774 *IDLE mode aspects for Non-Terrestrial Networks (NTN)*  Nokia, Nokia Shanghai Bell, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[2] R2-2009454 *Cell selection and reselection enhancements* Qualcomm Incorporated, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[3] R2-2009597 *Control Plane for Idle mode UE*  Xiaomi, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[4] R2-2010578 *Idle mode issues in NR NTN*  LG Electronics Inc, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[5] R2-2010453 *Satellite ephemeris in NTN*  InterDigital, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[6] R2-2008837 *Remaining Issues of IDLE and Inactive Mode for NTN* CATT, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[7] R2-2009255 *Idle mode procedures in NR NTN* Thales, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

[8] R2-2010765 *[AT112-e][104][NTN] Misc CP issues (Ericsson)* Ericsson, 3GPP TSG-RAN WG2 Meeting #112 Electronic Elbonia, 2 – 13 November 2020

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