3G PP RAN WG2 112e R2-2xxxxxx

Online November 2nd – 13th, 2020

Agenda Item: 9.2.2

Source: MediaTek

Title: [IoT-NTN] Applicability of TR 38.821 on eMTC/NB-IoT based NTN (MediaTek)

Document for: Discussion, Decision

# Introduction

Non-Terrestrial Networks (NTN) differ from terrestrial networks (TN) in terms of large propagation delay and wide geographical coverage of beam-spots (cells), thereby resulting in significant increase in round-trip delay (RTD). A new Study Item Description (SID) to enable NB-IoT/eTMC for supporting NTN [1] was approved in RAN#86 meeting. The new SI intends to reuse the conclusions in TR 38.821 [2], made as an outcome of Rel-16 NR-NTN SID. The conclusions of Rel-16 NR-NTN SI [1] contains some major recommendations on MAC (including Random Access and HARQ), RLC-PDCP, Idle Mode mobility and Connected Mode mobility. Furthermore similar to NR-NTN Work Item Description (WID) [3], the Rel-17 NB-IoT/eTMC NTN SID [1] explicitly mentions GNSS capability in the NB-IoT and eMTC devices as a working assumption. As a result, the devices not having GNSS capability are not considered here.

This document discusses parts of TR38.821 [2] that can be re-used or not re-used for NB-IoT/eMTC support for NTN, identify points for necessary discussions and achieve possible agreements. Following the traditional convention of RAN2, it is assumed that “*All features of current NB-IoT and eMTC releases (including MO EDT and MT EDT) are assumed to be included, unless otherwise mentioned*”. Specifically this email discussion document covers the following aspects:

* General aspects related to timers
* Aspects related to HARQ operation
* RAN2 Aspects related to Idle Mode
* RAN2 Aspects related to Connected Mode

Moreover, the majority proposals [4–12], with focus on applicability of parts of TR38.821 [2] in eMTC/NB-IoT NTN are also included. Some additional issues, identified and corresponding candidate solutions are also included for companies to provide views for potential down-scoping:

* **[AT112-e][035][IoT-NTN] Applicability of TR 38.821 (MediaTek)**
* Scope: Discuss the applicability of TR 38.821 and proposals, mentioned in the contributions in 9.2.2 of RAN2-112e, focusing on this aspect. The intention is to identify design alternatives and, whenever possible, also narrow down the proposals.
* Intended outcome: summary of the email discussion with:
	+ List of agreeable proposals (if any)

Please note the following deadline:

* **Deadline (for companies' feedback): November-09 12:00 (UTC)**

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# Enhancements in User Plane

## MAC

Table 7.1-1 in TS 38.821 [2] also mentions the delay constraint in the worst case scenarios for NR-NTN.

Table 1: Maximum Round Trip Delay for different reference scenarios, see Table 4.2-2 in [2]

|  |  |  |  |
| --- | --- | --- | --- |
|  | Orbit, payload | Max. RTD | Max Differential Delay |
| Scenario A | GEO, transparent | 541.46ms | 10.3ms |
| Scenario C | LEO, transparent | 25.77ms (600km)41.77ms (1200km) |  3.1ms |

Large propagation delay and wide geographical coverage of beam-spots (cells) result in significant increase in round-trip delay (RTD) and delay difference in eMTC/NB-IoT based NTN. The effects of this high RTD and delay difference were discussed and analysed during the Rel. 16 NR-NTN Study Item (SI). Based on this study, RAN2 made the following recommendations for Random Access (RA), Scheduling Request (SR) and Discontinuous Reception (DRX), in Section 9.2 of 3GPP TR 38.821 [2].

|  |
| --- |
| - Random access:* Definition of an offset for the start of the ra-ResponseWindow for NTN and extension of the ra-ResponseWindow duration to support UE without location information.
* Introduction of an offset for the start of the ra-ContentionResolutionTimer to resolve Random access contention
* Solutions for resolving preamble ambiguity and extension of RAR window.
* Adaptations for UEs with GNSS capabilities; timing advance and msg3 scheduling.

- Timing advance: TA calculation and signaling adaptation to deal with NTN maximum round trip delay in LEO and GEO scenarios for UE with and without UE location information.- DRX: * If HARQ feedback is enabled, an offset should be added for drx-HARQ-RTT-TimerDL and drx-HARQ-RTT-TimerUL.
* If HARQ is turned off per HARQ process, adaptions in HARQ procedure may be required
* Options for UE power saving for SR and CFRA can be discussed during work item phase

- Scheduling Request: Extension of the value range of sr-ProhibitTimer.HARQ* For NTN the network could disable uplink HARQ feedback for downlink transmission at the UE receiver e.g. to support long propagation delays. Even if HARQ feedback is disabled, the HARQ processes are still configured. Enabling / disabling of HARQ feedback is a network decision signalled semi-statically to the UE by RRC signalling. The enabling / disabling of HARQ feedback for downlink transmission should be configurable on a per UE and per HARQ process basis via RRC signalling.
* For NTN the network could disable HARQ uplink retransmission at the UE transmitter. Even if HARQ uplink retransmissions are disabled, the HARQ processes are still configured. The enabling / disabling of HARQ uplink retransmission could be configurable on a per UE, per HARQ process basis. Details can be decided in a normative phase. And the LCP impact caused by disabling the HARQ uplink retransmission configuration can be discussed in the WI phase.
 |

Based on the reference scenarios and major parameters for NR-NTN, mentioned in 3GPP 38.821 [1], we can conclude that the maximum total RTD for GEO NTN is almost 541.46ms. Similarly, the maximum RTD for LEO NTNs 12,200kms altitude are 25.77ms and 41.77ms at 600kms and 1,200kms altitudes respectively. The maximum differential delay (i.e. the maximum difference of RTD experienced by two devices in the same beam-spot) is 10.3ms and 3.1ms for GEO and LEO NTNs respectively.

### General Aspects Related to Timers

Similar to NR-NTN, the high RTD in eMTC/NB-IoT NTN will lead to expiry of most of the MAC timers. For example, the RAR might not be received by the device within the time interval of ra-ResponseWindowSize, having values specific to terrestrial networks. The high RTD might also led the device to not receive msg. 4 within the expiry of mac-ContentionResolutionTimer. The same will be true for SR Prohibit timer, as it will expire even before the device receives the UL grants (in PDCCH) for PUSCH transmission. R2-2008899 and R2-2010288 suggested that the challenges associated with the expiry of MAC timers in NR-NTN remains the same in eMTC/NB-IoT NTN and high RTD is the primary cause of this challenge:

**Question 1: Do companies agree that the challenges associated with the expiry of MAC timers in NR-NTN remain the same in eMTC/NB-IoT NTN and high RTD of NTN is the primary cause of this?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree |  |
| OPPO | Agree |  |
| ZTE | Agree |  |
| Ligado | Agree |  |
| Lenovo | Agree |  |
| Apple | Agree |  |
| Xiaomi | Agree |  |
| Nokia | Agree with comment | The channel repetitions should also be considered for the MAC timers setting. |

Note that, similar to the assumption of GNSS capable UE in Rel-17 NR-NTN WID [3], the Rel-17 IoT-NTN SID [1] a GNSS capable eMTC/NB-IoT device can use the offset to adjust the MAC timers. According to the recent NR-NTN agreements [17], this offset will be used to adjust the start of major MAC timers, e.g. RAR Window, CR timer and SR Prohibit timer. The majority contributions in RAN2-112e suggested the use of similar offsets to adjust the MAC timers: R2-2008899, R2-2009072, R2-2009450, 2009591, R2-2009988, R2-2010247, R2-2010288.

**Question 2: Do companies agree that an offset could be used to delay (adjust) the start of ra-ResponseWindow, mac-ContentionResolutionTimer and SR Prohibit timer similar to NR-NTN? FFS is the offset estimation process and offset value.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree |  |
| OPPO | Agree | An offset should be used for the above MAC timers to accommodate the large UE-gNB RTD in NTN. |
| ZTE | Partially agree | There has been discussion on the offset to delay the start of some timers while in R17 NR NTN WI but only the following agreements have been reached so far:*From RAN2 perspective, an offset is applied to the start of ra-ResponseWindow in NTN for both LEO and GEO scenarios**An offset to the start of the ra-ContentionResolutionTimer is introduced for both LEO and GEO scenarios.*Thus, we agree that an offset could be used to delay the start of *ra-ResponseWindow* and *ra-ContentionResolutionTimer* as in NR NTN. For other timers, more discussion is required and we can wait for more progress of NR NTN to avoid parallel discussion.Moreover, for eMTC/NB-IoT UE, there is already an offset before the start of *ra-ResponseWindow* as defined in clause 5.1.4 of TS 36.321. For eMTC, this offset is 3 subframes. For NB-IoT, the offset is 4 or 41 subframes which is determined according to the used preamble format and the number of NPRACH repetitions. This should be taken into account in further discussion, e.g., whether to extend the existing offset or introduce a new one. |
| Ligado | Agree |  |
| Lenovo | Agree | Can align with NR-NTN agreements. |
| Apple | Agree |  |
| Xiaomi | Agree |  |
| Nokia | Partially Agree | Apply offset to the start of ra-ResponseWindow and mac-ContentionResolutionTimer is fine while it is FFS for SR Prohibit timer. There is no conclusion in NR NTN about how to extend the value range of sr-ProhibitTimer (e.g. adding offset or extending higher value). |

It is mentioned in 38.821 [2] that “for UE with location information, if the exact round trip delay can be estimated as an offset to delay the ra-ResponseWindow, there appears to be no need for extending the ra-ResponseWindow.” Following the same method, the contributions R2-208899 and R2-2009450 in RAN2-112e suggested that there is no need to extend RAR Window and the current size is enough. Moreover, it is mentioned in 3GPP TS 36.331 that both RAR Window and CR timer can have a maximum value of 10.24 seconds for FDD and 20.48 seconds for TDD, which is already large enough. However, the contribution R2-2009072 suggested RAN2 to discuss whether to extend the length of the ra-ResponseWindow for eMTC/NB-IoT over NTN.

**Question 3: Do companies agree that similar to NR-NTN there is no need to extend the ra-ResponseWindow for eMTC/NB-IoT over NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG |  | If the pre-compensation is supported, it is not need to extend the RAR window. Otherwise, RAN2 should discuss the extension of the RAR window.  |
| OPPO | Agree, but | We have concerns to take GNSS capability as a working assumption in study for NB-IoT/eMTC over NTN, due to the low cost and low complexity requirement for these device types. With the assumption of UEs without GNSS capability, a UE could not estimate UE-gNB RTD delay, in which case UE could not use UE-gNB RTD delay as the offset to ra-ResponseWindow.But we think even for UEs without GNSS capability, the current ra-ResponseWindow length for eMTC/NB-IoT is sufficient to cover the maximum differential RTD within a cell to ensure all the UEs in a cell with different RTD could receive Msg2 within the ra-ResponseWindow. So no need to extend the ra-ResponseWindow. |
| ZTE | Disagree | There is ongoing discussion in NR NTN about whether to extend the *ra-ResponseWindow* and no agreement has been made so far. We can wait for more progress in NR NTN to avoid parallel discussion.Technically, as the parameter w.r.t the satellite for IoT, e.g., beam size and elevation angle, is still pending including link budget, also whether to support coverage enhancement is not clear, now it’s hard to decide whether the current length of the *ra-ResponseWindow* is enough or not. For example, if coverage enhancement (e.g. lagre repetition number will be used) is supported for IoT over NTN, the propagation delay + large repetition delay may vary in a large range, then the timer value range extension may be needed. |
| Ligado | Agree |  |
| Lenovo | / | We can wait for NR-NTN agreements and see if applicable to IoT, e.g. the offset could be derived from TA pre-compensation which may be an optional capability. |
| Apple |  | Agree with LG. If pre-compensation is supported by UE. |
| Xiaomi |  | We can wait for NR-NTN agreements. |
| Nokia | Disagree | For eMTC, the maximum value for ra-ResponseWindowSize is 400ms, if more PDCCH repetition transmissions should be supported to achieve the coverage MCL target, it may require extending the timer even UE can estimate exact RTD. We think it’s better keep this open until RAN1 conclude the required repetition number of channels for IoT NTN.Furthermore, we have concern on the scenario UE being indoor/in container/carriage which may cause inaccurate RTD estimation thus may cause extension of ra-ResponseWindowSize timer. Please refer to our additional comments in Q5. |

### RACH Capacity Evaluation

The PRACH capacity is determined by the PRACH periodicity, UE density and the cell size. It is mentioned in R2-2009072 that for NB-IoT, the periodicity of PRACH is larger than 40ms. This avoids the overlapping of preambles in the network. But for eMTC over NTN, the limitation of PRACH periodicity should be considered and RACH capacity should be evaluated.

**Question 4: Do companies agree that for eMTC/NB-IoT over NTN, PRACH capacity need to be re-evaluated to check whether they can support the large cell size of GEO/LEO?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Yes |  |
| OPPO | Agree |  |
| ZTE | Agree | As mentioned above, roughly the PRACH capacity can be evaluated according to PRACH periodicity, UE density and the cell size. But as UE density, coverage requirements etc. are still under discussion, we agree PRACH capacity need to be re-evaluated after these aspects are decided.Moreover, we think exact evaluation on RACH capacity should be done in RAN1. In some RAN1 contribution in this meeting, preliminary check is done. Evaluation would be updated after the conclusion of new satellite parameters. |
| Ligado  | Disagree | PRACH capacity depends on service provider’s unique offering/traffic usage. Implementation specific, not for 3GPP to analyze. |
| Lenovo | Agree |  |
| Apple | Agree |  |
| Xiaomi | Agree |  |
| Nokia | Agree  |  |

### Timing Advancements

For enhancements in Timing Advancements (TA), R2-2009072 suggested that UE can estimate the user specific TA and be indicated the common TA by the network. R2-2009450 and R2-2010247 recommended to use UE-specific TA calculated by using GNSS. R2-2009450 has also mentioned that RAN1 needs to decide about studying the solution for common TA. However, the rapporteur believes that RAN1 is working on TA and RAN2 needs to wait for RAN1’s decision and conclusions for TA.

**Question 5: Do companies agree that RAN2 should wait for RAN1’s decision on TA in eMTC/NB-IoT NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree | RAN2 should wait for RAN2 decision. |
| OPPO |  | With the assumption of UEs without GNSS capability, we should focus on solutions for common TA. |
| ZTE | Agree with comments | There is ongoing discussion in RAN1 for NR NTN about the timing advance. We can wait for the progress and check whether the agreements made for NR NTN are applicable for eMTC/NB-IoT NTN or not.  |
| Ligado | Agree with comment | For NTN-IoT, only UE specific, GNSS based TA is in scope.  |
| Lenovo | Agree | We can wait for NR-NTN agreements and see if applicable to IoT. |
| Apple | Agree |  |
| Xiaomi | Agree |  |
| Nokia | Agree with comments | For the TA estimation by UE via using GNSS, we think RAN2 need to clarify below two items:1. Whether the case where GNSS and IoT channels have different coverage should be considered. E.g. PRACH can work (with repetitions) in extended coverage area(e.g. indoor/in container/carriage) while GNSS cannot work well to estimate TA.2. As indicated in the WID, simultaneous GNSS and NTN NB-IoT/eMTC operation is not assumed, the question is: can the IoT UE estimate and pre-compensate timing offset for each PRACH repetition and PUSCH repetition in LEO (as opposed to just pre-compensate the first PRACH transmission) ? |

### Aspects Related to HARQ

It was recommended in TR 38.821 [2] that HARQ could be semi-statically enabled/disabled per UE and per HARQ process basis. However, as mentioned in R2-2008900, unlike NR, NB-IoT and eMTC applications are not delay-sensitive and sustained high throughput is generally not required for eMTC/NB-IoT devices. Instead most of the transmissions are one-shot with pretty low throughput requirements. The delay requirement is typically as high as 10 seconds for the uplink. Moreover, the typical packet size and reporting intervals discussed for IoT are 50 bytes, 2 hours; 200bytes, 2 hours; 50 bytes, 24 hours and 200 bytes, 24 hours. Hence, even in the worst case scenario, transmitting 200bytes of data over a 10s delay budget requires a data rate of only 160bps. Such a low data rate requirement can be achieved with HARQ enabled, even after taking NTN RTD into account. Moreover, for control plane signalling messages, involving SRBs and MAC CEs, HARQ is very important as other recovery mechanisms, like RLC retransmissions in AM, is not possible for msg.3 and MAC CEs. Hence, R2-2008900, R2-2009072, R2-2009113 and R2-2010247 recommend that there is no need to disable HARQ for eMTC/NB-IoT NTN. On the other hand, R2-2009450 suggested to study the disabling of HARQ retransmissions. R2-2009988 is also open for disabling HARQ feedback if required. Finally, R2-2010288 suggested to wait for further progress in NR-NTN before discussing HARQ in eMTC/NB-IoT NTN.

**Question 6: Based on the low data rate requirements and high delay budget, do companies agree that unlike NR-NTN, there is no need to disable HARQ feedback in eMTC/NB-IoT NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree |  |
| OPPO | Agree | There is no strong motivation to introduce disabling HARQ feedback for NB-IoT and eMTC in NTN. |
| ZTE | / | Before evaluating whether to disable HARQ in eMTC/NB-IoT NTN, the date rate requirements and delay budget should be clarified.Technically, the large NTN RTD would have bad impacts and may cause the previous date rate requirements and delay budget in NB-IoT/eMTC can no longer be guaranteed.If it’s still required that date rate requirements and delay budget are same as that in TN NB-IoT/eMTC, we may need to consider either more HARQ processes or disabling HARQ or maybe other options. But for IoT, more HARQ processes may need larger buffer size and increase device complexity. Disabling of HARQ process may have procedure impacts on EDT/PUR. All these issues should be taken into account further.If it’s tolerable of a kind of worse date rate and delay performance (as NB-IoT and eMTC are not delay-sensitive and generally no need of high throughput), maybe we don’t need the above schemes for IoT over NTN. |
| Ligado | Disagree | We would prefer to use other methods of packet repetition, such as ABR. Ability to disable HARQ is important to us. |
| Lenovo | / | It may be too early to decide. We need to first consider the service requirements of eMTC/NB-IoT and see if tolerable in NTN. |
| Apple | / | Too early to decide.  |
| Xiaomi |  | The further evaluation may be needed.  |
| Nokia | Disagree | The throughput and latency requirement should be addressed first to facilitate HARQ operation design for IoT NTN. E.g. Software update/reconfiguration as defined in TR45.820-E.2 may need high throughput for large payload sizes (200 - 2000 bytes) to complete software updates. We suggest keep it open for further study. |

If HARQ is enabled, HARQ-RTT-Timer and UL-HARQ-RTT-Timer respectively specify the minimum number of subframes before a DL assignment and UL grant for HARQ retransmission is expected. However the DL assignment or UL grant for HARQ retransmissions might not be received due to the high RTD in NTN. Hence, like other MAC timers, it is required to update the corresponding HARQ timers in eMTC/NB-IoT NTN. The following contributions suggested to follow the NR-NTN agreements [17] to extend the HARQ timers by using the offset: R2-2008899, R2-2009072, R2-2009113, R2-2009591 and R2-2010247. On the other hand, R2-2009450 recommended to study further about how to update the timer for HARQ RTT timer.

**Question 7: Do companies agree that an offset will be used to delay the start of HARQ-RTT-Timer and UL-HARQ-RTT-Timer in eMTC/NB-IoT NTN similar to NR-NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Yes |  |
| OPPO | Agree |  |
| ZTE | / | There is ongoing discussion in NR NTN for the offset to delay the start of the HARQ RTT timers but no conclusions have been reached so far. We can wait for more progress in NR NTN and check whether the agreements are applicable for eMTC/NB-IoT NTN afterwards.Technically, with the same justification as that for introducing offset to the start of *ra-ResponseWindow* and the start of ra-*ContentionResolutionTimer*, an RTT related offset may need to be considered for HARQ RTT timer definition in IoT over NTN. |
| Ligado | Agree |  |
| Lenovo | / | We can wait for NR-NTN agreements and see if applicable to IoT, e.g. the offset could be derived from TA pre-compensation which may be an optional capability. |
| Apple | / | Agree with Lenovo.  |
| Xiaomi |  | We can wait for more progress in NR NTN and then decide whether an offset is applicable to IoT. |
| Nokia | Agree |  |

### UL Scheduling

Uplink scheduling enhancements/scheduling options as below are studied and captured in TR38.821 [2] for NR NTN with the motivation to reduce scheduling latency. In RAN2-111e meeting, it was agreed that at least configured grant and BSR over 2-step RACH should be studied. The contribution in R2-2009450 recommended to study configured grant for BSR in eMTC and RACH-based SR in NB-IoT. However, as suggested in R2-2009988, for IoT over NTN, latency is not the critical performance requirement. Therefore the target for latency reduction are not very necessary. The contribution in R2-2010288 also supported this view.

**Question 8: Do companies agree that unlike NR-NTN, as latency is not a critical performance requirement in eMTC/NB-IoT devices, UL scheduling enhancement for delay reduction is not necessary for eMTC/NB-IoT over NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree |  |
| OPPO | Agree |  |
| ZTE | / | The latency requirement for eMTC/NB-IoT over NTN should be clarified first before using it to evaluate UL scheduling enhancements.For NT NB-IoT, UL SPS for BSR and dedicated SR with/without HARQ-ACK are already supported for further latency and power consumption reduction. This can be reused in NTN, but the maximal value of *semiPersistSchedIntervalUL* may be not enough and may need to be extended. For eMTC, the SR latency would be large with large NTN RTD, further enhancements may be needed with additional consideration on UE power saving and signalling overhead reduction. For example, BSR over 2-step RACH can be considered.  |
| Ligado | Disagree | Support using common procedures for Uplink scheduling with NR-NTN. |
| Lenovo | / | It may be too early to decide. We can wait for NR-NTN agreements and see if applicable to IoT, and delay reduction is not the only reason of UL scheduling enhancement in NR-NTN. |
| Apple | / | Too early to decide. |
| Xiaomi | Agree |  |
| Nokia | Agree |  |

## RLC and PDCP

### RLC and PDCP Timers

Similar to the MAC timers, it is suggested in NR-NTN [2, 18] that RLC/PDCP t-Reordering timer needs to be extended. The contributions in R2-2009072, R2-2010247 and R2-2010288 suggested to follow the NR-NTN solutions. However, R2-2008899 pointed out that unlike NR-NTN, in eMTC/NB-IoT NTN the data rates are much lower, and data transmission will consist of a pretty small number of packets over a relatively long period of time. Hence, R2-2008899 suggested that there is no need to extend RLC t-Reordering timer and the existing range of the RLC t-Reordering timer is sufficient. Note that there is already a consensus and agreement in NR-NTN RLC PDCP email discussions [18] that there is no need to extend RLC (other than t-Reordering timer) and PDCP timers.

**Question 9: Do companies agree that unlike NR-NTN there is no need to extend RLC t-Reordering timer in eMTC/NB-IoT NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree |  |
| OPPO | Agree | Just to clarify that in NR-NTN RLC PDCP email discussions, majority companies don’t think PDCP t-Reordering timer needs to be extended until any new QoS requirement (5QI) is defined.We think the current maximum value (1600ms) of RLC t-Reordering might not be sufficient to cover a few HARQ retransmission for NB-IoT in NTN and may need to be extended. |
| ZTE | / | There is ongoing discussion in NR NTN on whether to extend the RLC t-Reordering timer without reaching any agreement so far. We can wait for more progress and check the applicability in eMTC/NB-IoT NTN afterwards.Technically, in order to avoid too much RLC reordering triggered by unnecessary PDU re-transmission, the RLC *t-Reordering* timer may need to be extended. But this is just initial thinking and this may also depends on the agreements from other issues, e.g., whether disabling of HARQ process is supported.  |
| Ligado  | Disagree | Our evaluation showed that t-reordering needs to be extended by RTT and additional factor. |
| Lenovo | / | Unless new 5QI is introduced, there is no need to extend RLC t-Reordering timer. However, this has not been decided in NR-NTN so we can wait. |
| Apple | Agree |  |
| Xiaomi |  | Too early to decide and we can wait for agreements in RAN1. |
| Nokia | Disagree | t-Reordering timer is to re-order packet from different HARQ or retransmissions, which may be impact by RTD and repetitions. |

### RLC and PDCP SN

Using a similar argument, it could be shown that the existing Sequence Number (SN) length fields are enough for RLC and PDCP SN in eMTC/NB-IoT NTN. R2-2010288 and R2-2008899 have pointed out that similar to NR-NTN agreements [18], there is no need to extend RLC and PDCP SN length for eMTC/NB-IoT NTN.

**Question 10: Do companies agree that there is no need to extend RLC and PDCP SN length for eMTC/NB-IoT NTN, similar to NR-NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree |  |
| OPPO | Agree |  |
| ZTE | Agree | The SN value range for eMTC/NB-IoT is already large enough, and it is not impacted by RTD, so there may be no need to extend the value range. |
| Ligado | Agree |  |
| Lenovo | Agree |  |
| Apple  | Agree |  |
| Xiaomi | Agree |  |
| Nokia | Agree |  |

# Enhancements in Control Plane

## System Information Broadcast

Network can provide satellite specific information to UE by using System Information (SI) messages. This includes satellite ephemeris data and other necessary parameters. The contributions in R2-2009072 suggested to study how to provide the cell beam related information in system information. Similarly, R2-2009450 also suggested to study details on satellite information that needs to be provided to UE and check if multiple beams per cell can help in reducing RRC signalling overhead during handover. However, in RAN2#111e meeting, it was agreed to postpone the discussion on whether to introduce a new SIB until we more progress on the content of SI is decided. As suggested in R2-2009592, for NB-IoT/eMTC, the SI should wait for the conclusions from NR NTN.

**Question 11: Do companies agree that RAN2 should aim to reuse NR-NTN solutions for providing satellite ephemeris data and other information using System Information (SI) message for eMTC/NB-IoT NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Not yet | It was agreed to use ephemris information for cell selection/reselection, but how to provide it is still FFS. So the question is premature now. |
| OPPO | Disagree | If GNSS capability cannot be assumed for eMTC/NB-IoT, then we don’t think we can reuse NR-NTN solutions. |
| ZTE | Agree with comments | The satellite ephemeris data is needed for UE to perform TA pre-compensation and location determination. So we assume they are needed in IoT over NTN. But the satellite ephemeris data provision in NR NTN is still under discussion and it may also be provided via other means than system information (e.g. via pre-configuration or NAS signalling).Other NTN specific information is still under discussion in NR NTN with no conclusions made so far.We should wait for more progress in NR NTN discussion. |
| Ligado | Agree |  |
| Lenovo | Agree but | We are OK with the principle that satellite ephemeris provision mechanism can be reused. But as the details are still in discussion in NR-NTN e.g. the format of ephemeris or whether to introduce new SIB, we can wait for the final agreement. |
| Apple | Agree | However, it is preferable to keep things open at this stage and decide later.  |
| Xiaomi | Agree | We also need to consider the case that UE hasn’t the GNSS capabilities. |
| Nokia | Agree with comments | For the beam related information in system information, it is not clear about the definition of cell beams. eMTC/NB-IoT does not use concept of beams as NR. So, we propose that, NR-NTN solutions for providing satellite ephemeris data and other information using System Information (SI) message can be the baseline for IoT NTN while detail content is FFS. |

## Idle Mode

For GEO, the satellite is static with respect to the device. Hence, the cell reselection procedure of NB-IoT and eMTC over NTN can be same as the legacy. However, for LEO with earth-moving cells, the serving satellite may change quite frequently. This might result in frequent cell selection/reselection.

### Cell Selection/Reselection

RAN2 has recently discussed cell selection/reselection in RAN2#111e and reached on some basic agreements. The contribution in R2-2009591 suggested to reuse the agreements on cell selection/reselection achieved in RAN2#111e meeting in NB-IoT/eMTC NTN. Similarly, R2-2010288 has also mentioned that the analysis on idle mode procedures can be reused as a baseline. R2-2010247 has also supported this concept while ensuring that the process provides sufficient precision for NB-IoT and eMTC devices.

**Question 12: Do companies agree that the agreements on cell selection/reselection for NR-NTN will be reused as a baseline in eMTC/NB-IoT NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree |  |
| OPPO | Disagree | If GNSS capability cannot be assumed for eMTC/NB-IoT, then we don’t think we can reuse NR-NTN solutions.In addition, it is still not clear what are the cell selection/reselection procedures in NR-NTN. |
| ZTE | / | High level to say, whether to reuse the agreements made in NR NTN for cell selection and re-selection should be evaluated case by case.So far the following agreements have been made:*Cell selection / reselection in NR is the baseline in NTN idle mode procedure**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**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)**The existing cell reselection priority configuration can be taken as a baseline in NTN. FFS on any further enhancement**Postpone the discussion on whether to introduce a new SIB until we have more progress on the content of NTN specific system information*Meanwhile, we think we’d better to identify what issues exist for IoT over NTN, then we can further discuss whether the agreements can be reused and how to reuse. Besides the issue mentioned above, e.g., the frequent cell selection/reselection due to frequent serving satellite change, another issue related to idle mode eDRX should also be considered (discussed in Q13). Furthermore, we want to indicate that priority based cell reselection is not supported in NB-IoT. That means, if we want to reuse some above agreements, maybe more work would be needed for NB-IoT than eMTC. |
| Ligado | Agree |  |
| Lenovo | / | Cell selection/reselection for NR-NTN is not clear so too early to decide. |
| Apple | Agree |  |
| Xiaomi | Agree with comments | IN NR NTN, UE GNSS capabilities is assumed and some solution will use the UE GNSS, however, if GNSS capability cannot be assumed for eMTC/NB-IoT, some NR NTN solutions can’t be reused. |
| Nokia | Agree |  |

The contribution in R2-2009072 has mentioned that it is possible that the serving cell that can be seen after eDRX cycle are totally different from the neighbour cells in the last eDRX cycle. On the other hand, the neighbour cells may be totally different for UEs with different eDRX cycle. Hence, R2-2009072 suggested that RAN2 should discuss the impact of eDRX cycle on cell reselection procedure in NB-IoT and eMTC over NTN.

**Question 13: Do companies agree that RAN2 should discuss the impact of eDRX cycle on cell reselection procedure in eMTC/NB-IoT over NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree |  |
| OPPO | Disagree | If a UE would suffer from frequent cell reselection, it should not be configured with such a long eDRX cycle. The impact of eDRX cycle on cell reselection procedure could be avoided by network implementation.If GEO scenario is prioritized, then we don’t have such frequent cell reselection issue. |
| ZTE | Agree | The eDRX is a NB-IOT and eMTC specific feature which is not used in NR, which should be taken into consideration in this SI.As mentioned in contribution, for NB-IoT/eMTC UE in the idle mode, measurement and evaluation requirements are defined based on eDRX cycle, if configured. Thus, if eDRX cycle is configured long, it may lead to untimely measurement and further result in untimely or unsuitable cell reselection. So we may need some related enhancements.We disagree the thinking about not configuring a long eDRX cycle for a UE in above comment. We think this is important for UE power saving and power saving is still one of requirements for IoT NTN UE. |
| Ligado | Agree |  |
| Lenovo | Agree | eDRX is important for IoT UE power saving and should be discussed considering NTN scenario. |
| Apple | Agree |  |
| Xiaomi | Agree |  |
| Nokia | Agree |  |

### Tracking Area Update

For earth-fixed NTN cells (beams), the legacy tracking area management of R13 can be reused for eMTC/NB-IoT over NTN. For earth-moving cells, in TR 38.821 [2], it is recommended to have earth-fixed tracking area. The contributions in R2-2009072, R2-2009591, R2-2010247 and R2-2010288 have recommended to reuse the same earth-fixed Tracking Area concepts of NR-NTN in eMTC/NB-IoT NTN.

**Question 14: Do companies agree that earth-fixed Tracking Area concept of NR-NTN should be reused in eMTC/NB-IoT NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree |  |
| OPPO | Agree, but  | We prefer to prioritize GEO scenario in R17 IoT NTN, in which case the legacy tracking area management could be reused. |
| ZTE | Agree |  |
| Lenovo | Agree |  |
| Apple | Agree |  |
| Xiaomi | Agree |  |
| Nokia | Agree |  |

TR 38.821 [2] has also recommended some solutions for improving Tracking Area Update (TAU) in NR-NTN. Recommended solutions involve broadcasting multiple TACs in a cell, or forming a list of TAC. The contribution in R2-2009072 suggested to reuse these solutions to solve the frequent tracking area update in in eMTC/NB-IoT over NTN. However, RAN2 is expected to discuss the TAU solutions for NR-NTN soon and reach possible agreements. Thus, it will be wise to wait for the agreements on TAU solutions in NR-NTN WI to be completed.

**Question 15: Do companies agree that RAN2 should wait until agreements regarding TAU are made in the NR-NTN WI, and reuse those for eMTC/NB-IoT over NTN, if applicable?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree |  |
| OPPO | Agree, but  | See our comments to Question 14. |
| ZTE | Agree | NR-NTN agreements can be used as baseline or start point. But whether these solutions for decreasing the TA update frequency would have negative impacts on paging capacity for eMTC/NB-IoT over NTN may need to be further considered as the paging capacity is very critical for IoT. |
| Ligado | Agree |  |
| Lenovo | Agree |  |
| Apple | Agree |  |
| Xiaomi | Agree |  |
| Nokia | Agree |  |

## Connected Mode

Connected mode mobility is quite different for NB-IoT and eMTC, as only RLF-based connected mode mobility is supported in NB-IoT. Thus, in NB-IoT, there is no measurement in connected mode and no handover.

### RLF-based Mobility in NB-IoT

The contributions in R2-2009072, R2-2009450 and R2-2009591 suggested to use the traditional RLF-based mobility solutions for NB-IoT over NTN. R2-2009072 further suggests to include outputs of R17 RLF-based NB-IoT mobility enhancements for NB-IoT over NTN. As Rel-17 based mobility enhancements are still under discussion, it would be premature to consider to discuss these solutions in the Study Item phase. The outcome of Rel-17 based mobility enhancements can be aligned in the Work Item phase.

**Question 16: Do companies agree to use Rel-16 RLF-based NB-IoT mobility as a baseline for mobility in NB-IoT over NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree |  |
| OPPO | Agree |  |
| ZTE | Agree | Agree to use the Rel-16 RLF based NB-IOT mobility as a baseline while the R17 RLF-based NB-IoT mobility enhancements should also be taken into consideration. As there are not much agreements for R17 RLF-based NB-IoT mobility enhancements, we’d better to postpone this issue.Technically, for NB-IoT over NTN, considering that the current RLM procedure couldn’t follow the movement of LEO and the current condition of triggering RLF may bring additional delay, we think the enhanced RLF trigger could be considered. |
| Ligado | Agree |  |
| Lenovo | Agree | RLF-based NB-IoT mobility should be baseline and we can discuss if further enhancement is needed for NTN scenarios. |
| Apple | Agree |  |
| Xiaomi | Agree |  |
| Nokia | Agree with comments | Further RLF triggered mobility enhancement can be discussed in IoT NTN due to the satellite movement in LEO. |

### Mobility and Handover in eMTC

For LEO NTN with earth-moving beams, due to the movement of satellite, frequent handover and handover for a large number of UEs may cause the heavy air interface signalling overload. This problem was studied in TR 38.821 [2] and some solutions, including Conditional Handover (CHO), are also suggested. The contributions in R2-2009072, R2-2009450 and R2-2009591 suggested to study the similar solutions. However, as mentioned in R2-2010247, Rel-17 RAN2 NR-NTN WI is currently in the process of making agreements on this solutions. Hence, it will be wise to wait until these agreements are made and subsequently check if any of these agreements could be reused for mobility in eMTC on NTN.

**Question 17: Do companies agree that RAN2 should wait until agreements regarding handover, including Conditional Handover, solutions for high handover rates, handover robustness are made in the NR-NTN WI, and reuse those for eMTC over NTN, if applicable?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Not sure | We are not sure whether such mobility enhancements scheme can be used by eMTC devices, regarding UE complexity. |
| OPPO | Agree, but | We prefer to prioritize GEO scenario in R17 IoT NTN, in which case mobility is not an essential issue. |
| ZTE | Agree with comments | For eMTC over NTN, the above mentioned problems also exist. So we agree to consider conditional handover for eMTC on NTN. But as eMTC doesn’t support 2-step RACH, the delay during the conventional handover may be more serious. Additional enhancements may also need.Another thing that needs to be discussed for eMTC over NTN is, if conditional handover is supported, whether it would be also applicable to the TN scenario? Shortly to say, we think this should be avoided as there has no explicit requirement for mobility enhancements for TN scenario. To perform conditional handover may involve unnecessary complexity or overhead for the eMTC UE. |
| Ligado | Agree |  |
| Lenovo | Agree but | We are OK with the principle to reuse NR-NTN if applicable. But as the details are still in discussion in NR-NTN e.g. new triggering conditions for CHO and implementation complexity, we can wait for the final agreement. |
| Apple | Agree  |  |
| Xiaomi | Agree |  |
| Nokia | Agree |  |

R2-2009450 has indicated that in RAN1#102e, it was agreed to support “one-beam per cell and multiple-beam per cell in existing NR specifications and are baseline for NR NTN”. Therefore, the contribution in R2-2009450 also suggested to study multiple beams per cell to reduce RRC signalling overhead in handover scenario. However the feasibility of introducing multiple beams per cell needs to be discussed and decided in RAN1. Hence, RAN2 should wait for RAN1’s suggestion regarding the introduction of multiple beams per cell.

**Question 18: Do the companies agree that RAN2 should wait for RAN1’s input on supporting multiple beams per cell for eMTC over NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| LG | Agree | RAN1 should discuss first for this issue. |
| OPPO | Agree | It is up to RAN1 to decide whether to support multiple beams per cell. |
| ZTE | / | Discussion on beam part may be triggered much later in RAN1. It’s fine to conduct parallel discussion in RAN2, e.g., issue analysis with RAN2 recommendation.In short, as mentioned in R2-2009072, in order to deal with the NTN cell capacity and frequent mobility issue, we see necessity to support multiple beams per cell for IoT over NTN. |
| Ligado | Agree |  |
| Lenovo | Agree |  |
| Apple | Agree  |  |
| Xiaomi | Agree |  |
| Nokia | Agree |  |

The contribution in R2-2010247 has also raised the problem of propagation delay differences while measuring cells from different satellites and suggested that as the issue is very similar to NR-NTN, the NR-NTN could be used as a baseline. However, note that for eMTC (in LTE) there are gaps, with the same frame structure as LTE. Thus unlike NR, there will be synchronization signals at every 5ms intervals. Hence, there should not be any issue as the gap will be long enough to find the neighbour cells.

# Other Issues

Note that although the TN-NTN mobility is mentioned in R2-2009988, it is not included in this email discussion as it is not in the scope of the Study Item [1].

Nokia: Regarding the exclusion of TN-NTN mobility, it is not very clear whether it is in the scope of the SI, but we think the justification section points towards a need. It says “IoT operation is critical in remote areas with low cellular connectivity”, i.e. there is a possibility of coverage from both TN and NTN. Furthermore, transportation is targeted as a key industry, and here we would also expect the UE to at least sometimes experience both TN and NTN network coverage. Finally, there is a note that the NTN shall be defined in a “complementary manner to terrestrial deployments” – it seems indicate inter-RAT functionality.

# Conclusions

**<To be updated after collecting all responses from the companies.>**

# References

1. RP-193235, “New Study WID on NB-IoT/eTMC support for NTN”, (MediaTek)
2. 3GPP TR 38.821-g00, “Solutions for NR to support non-terrestrial networks”, Technical Report, (Release 16)
3. RP-193234, “New WID: Solutions for NR to support non-terrestrial networks (NTN) (WID)”.
4. R2-2008899, “On User-Plane Timers in NB-IoT based NTN” (MediaTek)
5. R2-2008900, “On Disabling HARQ in NB-IoT based NTN”
6. R2-2009072, “Consideration on the applicability of NR NTN to IoT over NTN” (ZTE Corp., Sanechips.)
7. R2-2009113, “Discussion on NB-IoT and eMTC support for NTN” (OPPO)
8. R2-2009450, “Applicability of NR NTN SI and WI solutions” (Qualcomm Inc.)
9. R2-2009591, “Initial discussion on NB-IoT and eMTC NTN” (Xiaomi)
10. R2-2009988, “NB-IoT/eMTC features and applicability of NR NTN solutions for IoT over NTN” (Nokia, Nokia Shanghai Bell)
11. R2-2010247, “Applicability of NR NTN to NB-IoT/LTE-M UEs that support NTN”, (Ericsson)
12. R2-2010288, “Discussion on applicability of TR 38.821 to NTN NB-IoT”, (Huawei, HiSilicon)
13. 3GPP TS 36.321 V13.2.0, “NR; RLC protocol specification (Release 15)”
14. 3GPP TS 36.331 V13.8.0, “Radio Resource Control (RRC) protocol specification (Release 15)”
15. 3GPP TS 36.322
16. 3GPP TS 36.323
17. R2-2010455, “Summary of [Post111-e][908][NTN] RACH and HARQ feedback aspects”, (InterDigital)
18. R2-2008896, “[POST111e][909][NTN] Email Discussions Summary on RLC and PDCP aspects”, (MediaTek)
19. R2-2009803, “Report of [Post111-e] [911] [NTN] Connected mode aspects” (ZTE corporation, Sanechips)