3GPP RAN WG2 112e R2-20XXXXX

Online November 2nd – 13th, 2020

Agenda Item: 8.10.2.2

Source: MediaTek

Title: [POST111e][909][NTN] RLC and PDCP aspects (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). This high RTD calls for some changes and enhancements in RLC and PDCP. The Rel-16 Study Item (SI) on NR-NTN [1] concluded with some major recommendations for RLC and PDCP in Section 9.2 of 3GPP TR 38.821 [1]. Furthermore, the work item description (WID) [2] for Rel. 17 NR-NTN clarifies the assumption of UEs with GNSS capabilities. This document discusses proposals from [7 – 12] with focus on RLC and PDCP aspects in NTN. Some additional issues, identified in [8] and corresponding candidate solutions are also included for companies to provide views for potential down-scoping:

* **[POST111e][909][NTN] RLC and PDCP aspects (MediaTek)**
* Scope: Discuss the proposals in contributions in 8.10.2.2 of RAN2-111e, focusing on RLC and PDCP aspects of NR-NTN. The intention is to identify design alternatives and, whenever possible, also narrow down the proposals.
* Intended outcome: summary of the offline discussion with:
	+ List of agreeable proposals (if any)
	+ List of proposals that require online discussions in RAN2-112e

Please note the following deadline:

* Deadline (for companies' feedback): **Thursday, OCT-15 UTC 07:00**

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# Enhancements in RLC

## Updating RLC Timers

High RTD in NTN might result in expiry of some RLC timers. Thus, it is necessary to look into the major RLC timers and check if any possible extensions or updates are needed.

### *RLC t-Reassembly Timer*

RLC t-Reassembly timer is started when a PDU segment is received from lower layer, is placed in the reception buffer, at least one byte segment of the corresponding SDU is missing and the timer is not already running. The procedure to detect loss of RLC PDUs at lower layers by expiration of timer t-Reassembly is used in RLC AM, as well as in RLC UM [3]. The timer t-Reassembly can be configured by fixed values between *0 and 200ms* [3]. In terrestrial networks this timer covers the largest time interval in which the individual segments of the corresponding SDU have to arrive out of order at the receiver due to SDU segmentation and/or HARQ retransmissions. However, if HARQ is supported by NTN, an extension of the t-Reassembly timer is necessary, because *the timer should cover the maximum time allowed for HARQ transmissions*, which will probably be a value larger than the Round Trip Delay (RTD). Considering the maximum RTD for the NTN reference scenarios, defined during the Study Item phase (see Table 1), it is obvious that the maximum value of 200ms is not enough, if HARQ is supported by NTN.

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

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

The following contributions in RAN2-111e proposed an extension of RLC t-Reassembly Timer: R2-2006640, R2-2006703, R2-2006782 and R2-2007785. On the other hand R2-2007889 mentions the extension of value for timers if a new QoS requirement for NTN is defined.

**Question 1: Do companies agree that RLC t-Reassembly timer needs to be extended in NR-NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Agree | The value range of t-Reassembly timer should be extended to accommodate the maximum delay of successful transmission of all SDU segmentations of a SDU, which is related to RTD while HARQ feedback is enabled. |
| LG | Agree | Considering the RTD in NTN, the current maximum value 200ms is not sufficient. Larger value may need to be introduced.  |
| Xiaomi | Agree | If HARQ is enabled. |
| CMCC | Agree | To ensure correct PDU segments reassembling, the RLC t-Reassembly timer is needed to be extended in NTN system. |
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#### *Modification of RLC t-Reassembly Timer*

Based on the Tdocs submitted in RAN2-111e, RLC t-Reassembly timer could be updated in different ways:

* **Option 1**: Reuse the same formula of TR 38.821 using maximum RTD (common to all UEs), number of allowed HARQ retransmission attempts and offset to account for possible delays on UE and network side. This is mentioned in R2-2006640.

*t-Reassembly = RTD \* NHARQ-ReTx + scheduling\_offset (1)*

* **Option 2**: Modification of the formula, given in TR 38.821, according to R2-2006703, considering UE specific one way propagation delay from UE to gNB or vice versa, number of allowed HARQ retransmission attempts and scheduling offset per transmission.

*t-Reassembly = (2 \* ntn-propagationDelay + schedulingOffset) ∙ nrofHARQ-Retransmissions (2)*

* **Option 3**: Use a UE-specific offset for the start of t-Reassembly, as mentioned in R2-2006782.

From the options submitted, we first need to decide whether the extension of RLC t-reassembly timer will be UE-specific or common across all UEs in the same cell.

**Question 2a: Should the RLC t-reassembly timer be extended by using UE-specific delay or cell-specific (maximum) delay?**

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| --- | --- | --- |
| **Company** | **Supported Option(s)** | **Additional comments** |
| Spreadtrum |  | The formula of option 2 takes schedulingOffset into consideration for every HARQ feedback, which is more reasonable than option 1. Option 3 is less friendly than expanding the timer from implementation perspective. However, UE is agnostic to the formula. It’s up to gNB implementation to configure the t-Reassembly to UE. |
| LG |  | We do not understand the question. The extended value should be introduced in RRC IE and the network just configures the UE’s t-reassembly using the extended value.  |
| Xiaomi | depends on network implementation | From UE point of view, it only knows that a specific t-Reassembly timer is configured, without knowing whether it is a UE specific value or cell specific value. From network point of view, it can decide whether to use a UE specific value or cell specific value depends on range of the differential delay. But anyway, the t-Reassembly is per UE per RB configured.  |
| CMCC |  | The calculation formula of the t-Reassembly timer is not perceptible to the UE and depends on the network implementation. |
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If extension of t-reassembly timer is common across all UEs, the network can configure the UEs with the extended value range of RLC t-reassembly timer. However, for UE-specific t-reassembly timer, following Question 2a, we also need to decide the principle to be used for the extension.

**Question 2b: Companies are invited to select a principle for extending RLC t-reassembly timer:**

* **Option 1: Reuse the same formula of TR 38.821 (mentioned in Equation (1) above);**
* **Option 2: Modify the formula, given in TR 38.821 (mentioned in Equation (2) above), according to R2 2006703;**
* **Option 3: Use an offset for the start of t-Reassembly, as mentioned in R2-2006782;**
* **Option 4: Any other option.**

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| --- | --- | --- |
| **Company** | **Supported Option(s)** | **Additional comments** |
| Spreadtrum |  | UE is agnostic to the formula. It’s up to gNB implementation to configure the t-Reassembly to UE. |
| LG | Option 4 | Introduce extended value in RRC IE. |
| Xiaomi | Network implementation | There is no need to capture the formula in the spec. But the values to be extended can be based on either option 1 or option 2, not much difference. |
| CMCC |  | Please see our comments to Question 2a. |
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### *RLC t-PollRetransmit Timer*

As mentioned in 3GPP TS 38.322 [3], an Acknowledged Mode (AM) RLC entity can poll its peer AM RLC entity in order to trigger status reporting at the peer AM RLC entity. The RLC layer uses the Polling flag in the header to solicit a STATUS PDU from the peer RLC. This timer is used by the transmitting side of an AM RLC entity to retransmit a poll. The t-PollRetransmit timer is started after a poll has been sent. If the t-PollRetransmit timer expires, the transmitting RLC entity sends a poll and considers un-acknowledged SDUs for retransmission. As discussed during the Study Item, the current range for t-PollRetransmit Timer is large enough to cover all NTN deployments. Hence, as mentioned in R2-2006640, the t-PollRetransmit Timer does not need any extension.

**Question 3: Do companies agree that there is no need to extend t-PollRetransmit Timer?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Agree | The maximum configurable expiration time for *t-PollRetransmit* timer is 4000ms which covers the RTD of NTN. |
| LG | Agree |  |
| Xiaomi | agree |  |
| CMCC | Agree | The current value range for t-PollRetransmit Timer is sufficient in NTN system. |
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### *RLC t-statusProhibit Timer*

A STATUS PDU is sent to the peer RLC layer to acknowledge received RLC SDUs and RLC SDU segments. A STATUS PDU is triggered when (a) the peer RLC layer sets the Polling flag (P) in an AMD PDU, thus, soliciting a STATUS PDU, (b) t-Reassembly timer expires, or (c) t-StatusProhibit timer expires. RLC t-StatusProhibit timer is used by the receiving side of an AM RLC entity in order to prohibit transmission of a STATUS PDU. Status report is not triggered when timerStatusProhibit is running. As discussed during the Study Item, the current range for t-statusProhibit timer is large enough to cover all NTN deployments. Hence, it is mentioned in R2-2006640 that t-statusProhibit timer does not need any extension in NR-NTN.

**Question 4: Do companies agree that there is no need to extend t-statusProhibit timer?**

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| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Agree | The maximum configurable expiration time for *t-statusProhibit* is 2400ms which covers the RTD of NTN. |
| LG | Agree |  |
| Xiaomi | Agree |  |
| CMCC | Agree |  |
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## Extending RLC Sequence Numbers

According to 3GPP TR 38.821 [3], RLC sequence number space needed for a radio bearer depends on supported data rates, retransmission time, as well as the average size of the RLC SDUs. The basic formula for calculating the supportable RLC bit rate for one radio bearer is given by:

*RLC\_data\_rate = RLC\_SDU\_size ∙ 2SN\_length -1 / RetransmissionTime*,

3GPP TS 38.322 [3] specifies a RLC AM sequence number (*SN*) field length of 12bits and 18 bits. Depending on typical values of RLC\_SDU\_size, SN\_length, RTD, maxRetxThreshold and RetransmissionTime, the following values of RLC data rates are estimated in Section 7.2.2.2 of 3GPP TR 38.821[1].

Table 2: Supportable RLC bit rates for GEO NTN with transparent architecture

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| RLC\_SDU\_size | SN\_length | RTD | maxRetxThreshold | RetransmissionTime | RLC\_data\_rate |
| 500Byte | 18 | 541.46 ms | 1 | 1.5 s | 350 Mbps |
| 1500Byte | 18 | 541.46 ms | 1 | 1.5 s | 1 049 Mbps |
| 500Byte | 18 | 541.46 ms | 4 | 3.0 s | 175 Mbps |
| 1500Byte | 18 | 541.46 ms | 4 | 3.0 s | 524 Mbps |

Table 3: Supportable RLC bit rates for LEO NTN with transparent architecture

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| RLC\_SDU\_size | SN\_length | RTD | maxRetxThreshold | RetransmissionTime | RLC\_data\_rate |
| 500Byte | 18 | 25.77 ms | 1 | 75.0 ms | 6 991 Mbps |
| 1500Byte | 18 | 25.77 ms | 1 | 75.0 ms | 20 972 Mbps |
| 500Byte | 18 | 25.77 ms | 4 | 150.0 ms | 3 495 Mbps |
| 1500Byte | 18 | 25.77 ms | 4 | 150.0 ms | 10 486 Mbps |

For GEO satellite system with transparent architecture, having a retransmission time of 3.0s or 1.5s and an RLC SDU size of 500 bytes, the NTN target data rate of 360Mbps for airplanes connectivity cannot be achieved. As mentioned in R2-2007785, this is a motivation for extending the RLC SN.

However, it is mentioned in R2-2006640 that considering typical TCP segment sizes and usage of PDCP packet aggregation schemes, in almost all practical scenarios the possibility of getting a stream of consecutive 500bytes packets in airplanes connectivity is very less likely. Thus, in almost all practical scenarios, the average RLC SDU size will be much higher than 500bytes. On the other hand, applications involving small data packets (e.g. voice) typically does not have a high target data rate of 360 Mbps. Based on these observations, it is also argued that there is no need to extend the RLC SN length. Moreover, it is also mentioned in R2-2006782 that longer SN field length leads to larger AM\_Window\_Size, which would increase the amount of required memory for the UE buffer. This is not desirable from the perspective of UE implementation complexity. This conclusion is supported in R2-2006703, and R2-2007889.

**Question 5: Do companies agree that there is no need to extend RLC SN length?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Agree | The 18-bit RLC SN can support most of scenarios. For airplane, more than one UE can be set in a plane if more data rate is needed. |
| LG | Agree |  |
| Xiaomi | Agree |  |
| CMCC | Agree | NTN Scenarios with insufficient data rate are very limited, and it is unnecessary to extend SN for the corner cases. |
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# Enhancements in PDCP

## Updating PDCP Timers

Similar to RLC, high RTD in NTN might result in expiry of some PDCP timers. Thus, it is necessary to look into the major PDCP timers and check if any possible extensions or updates are needed.

### *PDCP Discard Timer*

In PDCP layer, a timer *discardTimer* is configured for each DRB. Upon reception of a PDCP SDU from upper layer, the transmitting PDCP entity starts the *discardTimer* associated with this PDCP SDU. As mentioned in 3GPP TS 38.323 [4], when the *discardTimer* associated with a PDCP SDU expires, or the successful delivery of a PDCP SDU is confirmed by PDCP status report, the transmitting PDCP entity shall discard the PDCP SDU. The discardTimer is configured in the range of *0.5ms and 1500ms* or can be switched off by choosing infinity [4]. The discardTimer mainly reflects the QoS requirements of the packets belonging to a service. In NTN, due to long propagation delay, HARQ and ARQ retransmission delay will increase greatly. So one open issue is whether to extend the value range of PDCP *discardTimer* to support NTN.

In order to prevent unnecessary expiry of PDCP discardTimer, it is proposed to extend the PDCP discard timer in R2-2006640 and R2-2006705. One possible solution is to extend the discardTimer by the UE’s pre-compensated RTD. On the other hand, it is mentioned in R2-2006782 and R2-2007889 that as QoS requirement is a main factor in the *discardTimer* configuration, for some delay sensitive service, *discardTimer* should be configured to a relatively small value, while for some other delay tolerant services *discardTimer* could be configured even to infinity, if the value of 1500ms is still not enough and there is no need to extend the PDCP Discard timer, at least until new QoS requirements are defined.

**Question 6: Do companies agree that PDCP Discard timer needs to be extended?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | No | The PDCP discardTimer mainly reflects the QoS requirements of the packets belonging to a service. So the timer is not related to the RTD in NTN. We think that it may be extended only if a new 5QI is defined. |
| LG | Disagree | The value of the discardTimer is configured based on the QoS requirement. Thus, without changing the QoS requirement, the discardTimer should not be extended.  |
| Xiaomi | Depends on SA2 | Discard timer mainly relates to QoS requirement of service, i.e. whether service can endure a packet arriving with certain delay without disfunction. It is SA2’s responsibility to decide whether NTN service requirement would be different from the existing one. |
| CMCC |  | DiscardTimer modification needs to be considered as a compromise with required memory and QoS requirements. |
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#### *Modification of PDCP Discard Timer*

If the companies agree Question 6, then it should be noted that PDCP Discard timer could be updated in different ways.

* **Option 1**: Extend the value-range of the PDCP discard timer by a fixed set of values.
* **Option 2**: Extend the discard timer by UE-specific RTD.

**Question 7: Companies are invited to select a preferred method for extending the PDCP Discard timer:**

* **Option 1: Extend the value-range of the PDCP discard timer by a fixed set of values**
* **Option 2: Extend the discard timer by UE-specific RTD**
* **Option 3: Any other option.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Supported Option(s)** | **Additional comments** |
| LG | Option 1 | If the extension of the PDCP discard timer value is needed, new extended value should be introduced in RRC IE. |
| Xiaomi | option 1 | option 1 is enough, network configures UE specific discard timer value from the value set based UE specific RTD. |
| CMCC |  | Please see our comments to Question6. |
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### *PDCP t-Reordering Timer*

In order to detect loss of PDCP Data PDUs, PDCP *t-Reordering* timer is started or reset when a PDCP SDU is delivered to upper layers [4]. The maximum configurable expiration time is 3000ms [5].

During the Study Item phase, a possible limitation regarding overall number of retransmissions in NTN has been identified. Like PDCP *discardTimer*, the PDCP *t-Reordering* timer is also related to the QoS requirements and should be modified, if new 5QI requirements are defined or to meet operator-specific 5QIs, as mentioned in R2-2006705. Thus the open issue is whether the PDCP *t-Reordering* timer should be extended for NR-NTN.

**Question 8: Do companies see a need to extend PDCP t-Reordering timer?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes / No** | **Additional comments** |
| Spreadtrum | No | The PDCP t-Reordering timer mainly reflects the QoS requirements of the packets belonging to a service. So the timer is not related to the RTD in NTN. We think that it may be extended only if a new 5QI is defined. |
| LG | No | The value of the t-Reordering is configured based on the QoS requirement. Thus, without changing the QoS requirement, the t-Reordering should not be extended. |
| xiaomi | depends on SA2 | Similar to discard timer, it mainly relates to QoS requirement of service, i.e. whether service can endure a packet arriving with certain delay without disfunction. It is SA2’s responsibility to decide whether NTN service requirement would be different from the existing one. |
| CMCC |  | How to modify the t-Reordering timer demands comprehensive consideration of QoS requirements. |
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## Extending PDCP Sequence Numbers

Similar to RLC sequence number space, PDCP sequence number space also depends on supported data rates, retransmission time, as well as the average size of the PDCP SDUs. The basic formula for calculating the supportable PDCP bit rate for one radio bearer is given by:

*PDCP\_data\_rate = PDCP\_SDU\_size ∙ 2PDCP\_SN\_length -1 / PDCP\_RetransmissionTime*,

3GPP TS 38.323 [5] specifies a PDCP sequence number (*SN*) field length of 12bits and 18 bits. Depending on typical values of PDCP\_SDU\_size, PDCP\_SN\_length, and PDCP\_RetransmissionTime, the following values of PDCP data rates are estimated in 3GPP TR 38.821[1].

Table 4: Supportable PDCP bit rates for GEO satellite systems with transparent architecture

|  |  |  |  |
| --- | --- | --- | --- |
| PDCP\_SDU\_size | pdcp-SN-Size | PDCP\_RetransmissionTime | PDCP\_data\_rate |
| 500 Byte | 18 | 1.5 s | 350 Mbps |
| 1500 Byte | 18 | 1.5 s | 1049 Mbps |
| 500 Byte | 18 | 3.0 s | 175 Mbps |
| 1500 Byte | 18 | 3.0 s | 524 Mbps |

Table 5: Supportable PDCP bit rates for LEO satellite systems with transparent architecture

|  |  |  |  |
| --- | --- | --- | --- |
| PDCP\_SDU\_size | pdcp-SN-Size | PDCP\_RetransmissionTime | PDCP\_data\_rate |
| 500 Byte | 18 | 75 ms | 6991 Mbps |
| 1500 Byte | 18 | 75 ms | 20972 Mbps |
| 500 Byte | 18 | 150 ms | 3495 Mbps |
| 1500 Byte | 18 | 150 ms | 10486 Mbps |

For GEO satellite system with transparent architecture, with a retransmission time of 3.0s or 1.5s and a PDCP SDU size of 500 bytes, the NTN target data rate of 360Mbps for airplanes connectivity cannot be achieved. As mentioned in R2-2007785, this could be a motivation for extending the PDCP SN.

However, similar to RLC SN, it is mentioned in R2-2006640 that considering typical TCP segment sizes in almost all practical scenarios the possibility of getting a stream of consecutive 500bytes packets in airplanes connectivity is very rare. Thus, in almost all practical scenarios, the average PDCP SDU size will be much higher than 500bytes. On the other hand, applications involving small data packets (e.g. voice) typically does not have a high target data rate of 360 Mbps. Based on these observations, it is also argued that there is no need to extend the PDCP SN length. Moreover, it is also mentioned in R2-2006782 that longer SN field length leads to larger AM\_Window\_Size, which would increase the amount of required memory for the UE buffer. This is not desirable from the perspective of UE implementation complexity. This conclusion is supported in R2-2006705, and R2-2007889.

**Question 9: Do companies agree that there is no need to extend PDCP SN length for NR-NTN?**

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| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Agree | The 18-bit SN can support most of scenarios. For airplane, more than one UE can be set in a plane if more data rate is needed. |
| LG | Agree |  |
| xiaomi | agree |  |
| CMCC | Agree | Please see our comments to Question5 for RLC SN. |
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# Other Open Issues

Additional issues regarding QoS requirements are raised in R2-2006705. It is argued in R2-2006705 that no new QoS classes have been defined for NTN in Release 17 by SA2. Considering GEO-NTN with transparent payload, the maximum round trip delay (RTD) is around 541.46 ms (i.e. maximum one-way propagation delay of 270.73 ms). This results in only the standardized 5QI 4, 72, 73, 74, 76, 6, 8 or 9 as candidate for selection. However, as the packet delay budget for these services is either 300ms or 500ms, neither HARQ nor RLC retransmission seems possible with current 5QI specifications.

Note: While 5QI requirements are not in the scope of RAN2, the timer values (e.g. PDCP t-Reordering Timer) should be discussed in RAN2.

Therefore R2-2006705 suggests the following options for discussion:

* Option 1: Send an LS to SA2, requesting to define new 5QI values for NR-NTN.
* Option 2: Discuss reasonable values for PDCP *t-Reordering* Timer to support NTN, including GEO scenarios for operator defined 5QIs.

As Option 2 is already included in Section 4.1.2, the only question remaining is whether an LS to SA2 is needed.

**Question 10: Should RAN2 send an LS to SA2 requesting to define new 5QI values that can meet NTN requirements (including GEO).**

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| --- | --- | --- |
| **Company** | **Agree / Disagree** | **Additional comments** |
| Spreadtrum | Disagree | SA2 will decide if a new 5QI is needed. If a new 5QI is defined, an LS will be sent to us. |
| LG | Agree |  |
| xiaomi | Agree to send LS | We only agree to send the LS to ask whether new 5QI is needed or not. It is SA2’s responsibility to decide whether to introduce new 5QI for NTN. |
| CMCC | Agree | RAN2 could consult whether the SA2 will define new 5QI for NTN. |
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# Summary

<To be generated pending outcome of company inputs>

# Conclusions

<To be generated by pending outcome of company inputs>

# References

1. 3GPP TR 38.821-g00, “Solutions for NR to support non-terrestrial networks”, Technical Report, (Release 16)
2. RP-193234, “New WID: Solutions for NR to support non-terrestrial networks (NTN) (WID)”.
3. 3GPP TS 38.322 V15.2.0, “NR; RLC protocol specification (Release 15)”
4. 3GPP TS 38.323 V15.2.0, “NR; PDCP protocol specification (Release 15)”
5. 3GPP TS 38.331 V15.8.0, “Radio Resource Control (RRC) protocol specification (Release 15)”
6. 3GPP TS 23.501 V16.4.0, “System architecture for the 5G System (5GS); Stage 2 (Release 16)”
7. R2-2006640, “RLC and PDCP Enhancements in NR-NTN” (MediaTek Inc.)
8. R2-2006703, “Enhancements for NTN on RLC Control Loops and Timers” (Nomor Research GmbH, Thales)
9. R2-2006705, “Enhancements for NTN on PDCP Control Loops and Timers” (Nomor Research GmbH, Thales)
10. R2-2006782, “Consideration on RLC and PDCP enhancements for NTN” (OPPO)
11. R2-2007785, “Consideration on UP timers and RLC/PDCP SN for NTN” (ZTE Corporation, Sanechips)
12. R2-2007889, “Discussion on RLC and PDCP aspects for NTN”, (LG Electronics Inc.)