3GPP TSG RAN WG2 Meeting #113e R2-210xxxxx

January 25th – February 5th, 2021

**Source:** Eutelsat, MediaTek

**Title:** Text proposal for TR 36.763 related to RAN2

**Agenda Item:** 9.2.1

**Document for:** Discussion and decision

# Introduction

This document contains Text Proposals for TR 36.763 [1] based on the SID description [2] and agreements in AI 9.2.1 and A.I. 9.2.2 at RAN2#112e further to RAN2 email and meeting discussions for the Study on Narrow-Band Internet of Things (NB-IoT) / enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN).

TPs are based on agreement as captured in RAN2#112-eChairman Report in A.I. 9.2.1 and A.I. 9.2.2 on:

- IoT NTN reference scenarios

- Supported Core Network connectivity

- IoT NTN devices density

- Applicability of TR 38.821

# Text Proposal for TR 36.763

--- Start of text proposal (Section 2) ---

# 2 References

The following documents contain provisions, which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications"

[2] 3GPP TR 38.811 v15.2.0: "Study on New Radio (NR) to support non-terrestrial networks (Release 15)"

[3] 3GPP TR 38.821 v16.0.0: "Solutions for NR to support non-terrestrial networks (NTN) (Release 16)"

[4] 3GPP TR 45.820 v13.1.0: "Cellular system support for ultra-low complexity and low throughput Internet of Things (CIoT) (Release 13)"

[5] 3GPP TS 22.261: "Service requirements for the 5G system; Stage 1 (Release 16)"

[6] R2-1901404: "IoT Device Density Models for Various Environments", Vodafone, RAN2 #105

[7] 3GPP TS 36.331: "E-UTRA Radio Resource Control (RRC) protocol specification (Release 16)"

[8] 3GPP TS 36.322: "E-UTRA Radio Link Control (RLC) protocol specification (Release 16)"

[9] 3GPP TS 36.323: "E-UTRA Packet Data Convergence Protocol (PDCP) specification (Release 16)"

[10] R2-2011275: "[IoT-NTN] Applicability of TR 38.821 (MediaTek)"

--- End of text proposal (Section 2) ---

--- Start of text proposal (Section 4.2) ---

## 4.2 IoT Non-Terrestrial Networks reference scenarios

This FS shall consider non-terrestrial networks for IoT service providing access to NB-IoT/eMTC user equipment in reference scenarios including:

● GEO and LEO orbiting scenarios;

● No inter-satellite link;

● Transparent payload;

● Fixed or steerable beams resulting respectively in moving or fixed beam footprint on the ground;

● Sub 6 GHz bands of interest.

IoT NTN scenarios A, B, and C are included in the study as shown in Table 4.2-1 below:

Table 4.2-1: IoT NTN reference scenarios

|  |  |
| --- | --- |
| NTN Configurations | Transparent satellite |
| GEO based non-terrestrial access network | Scenario A |
| LEO based non-terrestrial access network generating steerable beams (altitude at Nadir 1200 km and 600 km) | Scenario B |
| LEO based non-terrestrial access network generating fixed beams whose footprint move with the satellite (altitude at Nadir 1200 km and 600 km) | Scenario C |

--- End of text proposal (Section 4.2) ---

--- Start of text proposal (Section 5) ---

# 5 IoT-NTN Architecture

IoT NTN connectivity via EPC is supported.

Editor’s Note: Support for IoT NTN connectivity via 5GCN is under discussion.

GNSS capability in the UE is taken as a working assumption in this study for both NB-IoT and eMTC devices. With this assumption, UE can estimate and pre-compensate timing and frequency offset with sufficient accuracy for UL transmission.--- End of text proposal (Section 5) ---

--- Start of text proposal (Section 7) ---

# 7 Radio Protocol Issue and Solutions

## 7.1 Requirements and key issues

### 7.1.1 Delay

In order to reduce the standardization work, the table below is amended from TR 38.821 [3] to identify the worst case IoT-NTN scenarios to be considered.

Table 7.1-1: NTN scenarios versus delay constraints, Source [3]

| NTN scenarios | GEO transparent payload | LEO transparent payload |
| --- | --- | --- |
| Satellite altitude | 35786 km | 600 km |
| Relative speed of Satellite with respect to earth | negligible | 7.56 km per second |
| Min elevation for both feeder and service links | 10° for service link and 10° for feeder link |
| Typical Min / Max NTN beam footprint diameter (Note 2)  | 100 km / 3500 km | 50 km / 1000 km |
| Maximum propagation delay contribution to the Round Trip Delay on the radio interface between the gNB and the UE | 541.46ms (Worst case) | 25.77ms |
| Minimum propagation delay contribution to the Round Trip Delay on the radio interface between the gNB and the UE | 477.48ms | 8ms |
| Maximum Delay variation seen by the UE (Note 3) | Negligible | Up to +/- 40 µs/sec (Worst case) |
| NOTE 1: Regenerative scenario is not considered in this release.NOTE 2: The beam footprint diameter is indicative. The diameter depends on the orbit, earth latitude, antenna design, and radio resource management strategy in a given system.NOTE 3: The delay variation measures how fast the round trip delay (function of UE-satellite-NTN gateway distance) varies over time when the satellite moves towards/away from the UE. It is expressed in µs/s and is negligible for GEO scenarioNOTE 4: Speed of light used for delay calculation is 299792458 m/s. |

When several non-terrestrial network scenarios feature a maximum in terms of delay constraints, it is sufficient to study only one of these scenarios.

- NTN Scenario based on GEO with transparent payload for RTD and delay difference constraints

- NTN Scenario based on LEO with transparent payload and moving beams for the delay variation related constraint

As per the duplex mode:

- Down-prioritize TDD in this study item

- There is no TDD-specific timing requirements and solutions on layer 2 due to propagation delay.

## 7.2 User plane enhancements

### 7.2.1 MAC

The challenges associated with the expiry of MAC timers in NR-NTN remain the same in IoT-NTN and high RTT of NTN is the primary cause of this [10]. The following sections are adopted from TR 38.821 [3] with suitable amendments for IoT operation.

#### 7.2.1.1 Random Access

**Enhancement to random access (RA) response window**

*Problem Statement*

After transmitting the Random Access Preamble (Msg1), the UE monitors the PDCCH for the Random Access Response (RAR) message (Msg2). The RA Response window starts at a determined time interval after the preamble transmission. If no valid response is received during the RA Response window, a new preamble is sent. If more than a certain number of preambles have been sent, a random access problem will be indicated to upper layers.

In terrestrial communications, the RAR is expected to be received by the UE within a few milliseconds after the transmission of the corresponding preamble. In NTN the propagation delay is much larger and therefore, the RAR cannot be received by the UE within the specified time interval specified for terrestrial communications. Therefore, the behaviour of RA Response window should be modified to support IoT-NTN.

*Solution Overview*

Similar to NR-NTN [3], introduce an offset to delay the start of the RA Response window for IoT-NTN [10]. It is assumed that UEs can accurately calculate the Round Trip Delay using location information and use this offset to delay the start of the RA Response window. With this assumption, there is no need to extend the *ra-ResponseWindowSize* for IoT-NTN.

**Enhancement to contention resolution timer**

*Problem Statement*

When the UE sends an RRC Connection Request (Msg3), it will monitor for Msg4 in order to resolve a possible random-access contention. The *mac-ContentionResolutionTimer* starts after Msg3 transmission. The maximum configurable value of *mac-ContentionResolutionTimer* is large enough to cover the Round Trip Delay in NTN. However, to save UE power, the behavior of *mac-ContentionResolutionTimer* should be modified to support NTN.

*Solution Overview*

Similar to NR-NTN [3], introduce an offset to delay the start of the *mac-ContentionResolutionTimer* for IoT-NTN [10].

#### 7.2.1.2 Discontinuous Reception (DRX)

*Problem Statement*

The Discontinuous Reception (DRX) supports UE battery saving by reducing the PDCCH monitoring time. Several RRC configurable parameters are used to configure DRX. [7, TS36.331]

HARQ RTT Timer is the minimum duration before a downlink assignment for HARQ retransmission is expected by the MAC entity. In terrestrial communications this is configurable in the range of a few ms, which is too small for a communication-link with a satellite. UL HARQ RTT Timer is the same as HARQ RTT Timer, just for the uplink. If HARQ is supported by IoT-NTN, the handling of HARQ RTT Timerand UL HARQ RTT Timer, should be modified to support IoT-NTN.

Modification of the remaining timers related to DRX is not needed to support IoT-NTN, similar to NR-NTN [3].

*Solution Overview*

As the challenges associated with the expiry of MAC timers in NR-NTN [3] remain the same in IoT-NTN, it is assumed that the same solutions as NR-NTN for the start of HARQ RTT Timer and UL HARQ RTT Timer can be reused to support IoT-NTN [10].

#### 7.2.1.3 Scheduling Request

*Problem Statement*

A UE can use a Scheduling Request (SR) to request UL-SCH resources from the eNB for a new transmission or a transmission with a higher priority. SR transmission is configured by RRC. While the prohibit timer (*sr-ProhibitTimer*) is active, no further SR is initiated. The *sr-ProhibitTimer* will at latest expire after 560ms for eMTC and after 35840ms for NB-IoT [7] and initiate a SR. For GEO systems the value range may not be sufficient because of the large RTD. The *sr-ProhibitTimer* may have to be modified to support IoT-NTN.

*Solution Overview*

Editor’s Note: RAN2 should further discuss the value range of *sr-ProhibitTimer* for IoT-NTN.

#### 7.2.1.4 HARQ

Editor’s Note: As the date rates for IoT-NTN are significantly lower than the data rates of NR-NTN, RAN2 needs to discuss further if there is a need to disable HARQ feedback.

#### 7.2.1.5 Uplink scheduling

The typical procedure when data arrives in the buffer is to trigger a Buffer Status Report and if the UE does not have any uplink resources for transmitting the BSR, the UE will go on to do a Scheduling Request to ask for resources. Since the scheduling request is only an indication telling the network that the UE requires scheduling, the network will not know the full extent of the resources required to schedule the UE, thus first the network may typically schedule the UE with a grant large enough to send a BSR so that the network may schedule the UE more accordingly.

Based on these reasons, some enhancements for UL scheduling are discussed for NR-NTN. However, unlike NR-NTN, UL scheduling enhancements for delay reduction is not needed for IoT-NTN as latency is not a critical performance requirement for IoT devices [10].

### 7.2.2 RLC

#### 7.2.2.1 Reordering timer

*Problem Statement*

Both AM and UM modes use the *t-Reordering* timer to control the RLC wait interval for out-of-order MAC data before considering the missing data as lost and handing any received data off to the PDCP layer. The *t-Reordering* timer can be configured with fixed values between 0 and 1600ms [7].

*Solution Overview*

Editor’s Note: It is FFS if there is a need to extend RLC t-Reordering timer in IoT-NTN.

#### 7.2.2.2 RLC Sequence Numbers

In NB-IoT, the RLC sequence number (SN) size is 7 bits for AM and 5 bits for UM. In eMTC, 10bit and 16bit are specified as the maximum possible UM and AM SN field lengths [8]. The sequence number space needed for a radio bearer depends on the data rate that is to be supported, the retransmission time (i.e. the RTD, the number of retransmissions and the scheduling delay) as well as the average size of the RLC SDUs. As the data rates for IoT-NTN are significantly lower than NR-NTN, there is no need to extend the RLC SN length for IoT-NTN.

### 7.2.3 PDCP

#### 7.2.3.1 Discard timer

The transmitting PDCP entity shall discard the PDCP SDU when the *discardTimer* expires for a PDCP SDU or when a status report confirms the successful delivery [9]. The *discardTimer* can be configured up to 1500ms for eMTC and up to 81920ms for NB-IoT, or can be switched off by choosing infinity. The *discardTimer* mainly reflects the QoS requirements of the packets belonging to a service.

Editor’s Note: It is FFS if there is a need to extend PDCP *discardTimer* in IoT-NTN.

#### 7.2.3.2 PDCP Sequence Numbers

In NB-IoT, the PDCP sequence number (SN) size is 7 bits. In eMTC, the maximum possible PDCP SN field length is 18bits [9]. As the data rates for IoT-NTN are significantly lower than NR-NTN, there is no need to extend the PDCP SN length for IoT-NTN.

## 7.3 Control plane enhancements

Editor’s Note: RAN2 should wait for RAN1’s input on supporting multiple beams per cell for IoT-NTN

### 7.3.1 Idle mode mobility enhancements

#### 7.3.1.1 Tracking Area

*Problem Statement*

As outlined in 38.821 [3], satellites may provide very large cells, covering hundreds of kilometres, and consequently would lead to large tracking areas. In this scenario the tracking area updates (TAUs) are minimal, however the paging load could be high because it then relates to the number of devices in the tracking area.

Moving cells and consequently moving tracking areas would be difficult to manage in the network as the contrast between the TAU and the paging signalling load would be too extreme to find a practical compromise.

On one hand, small tracking areas would lead to massive TAU signalling for UE at the boundary between 2 TAs as illustrated in figure.



Figure 7.3.1.1-1: Moving Cells and Small tracking areas leading to massive TAU signalling

On the other hand, wide tracking areas would lead to high paging load in the satellite beams as illustrated in figure 7.3.1.1-2.



Figure 7.3.1.1-2: Moving Cells and wide tracking areas leading to higher Paging load

However, tracking areas must be dimensioned to minimise the TAUs as this is more signalling-intensive than paging on the network.

In practical tracking area design, one of the criteria affecting the performance and capacity is the limiting capabilities of MME/AMF platforms and the radio channel capacity.

Ping-pong effect generating excessive TAU, and it can be minimised by ensuring 10-20% overlaps between the adjacent cells and appropriate allocation of TAI List to UEs especially at the edge of cells/TAs.

*Solution Overview*

In order not to have TAU performed frequently by the UE triggered by the satellite motion, the tracking area should be designed to be fixed on ground. For NTN LEO, this implies that while the cells sweep on the ground, the tracking area code (i.e. TAC) broadcasted is changed, when the cell arrives to the area of next planned earth fixed tracking area location. The TAC broadcasted by the eNB needs to be updated as the eNB enters to the area of next planned tracking area. When the UE detects entering a tracking area that is not in the list of tracking areas that the UE previously registered in the network, a mobility registration update procedure will be triggered.



Figure 7.3.1.1-3: An example of updating TAC and PLMN ID in real-time for scenario C2 and D2

As shown in Figure 7.3.1.1-3, network updates the broadcast TAC in real time according to the ephemeris and confirms that the broadcast TAC is associated with the geographical area covered by the satellite beam. UE listens to TAI = PLMN ID + TAC and determines to trigger registration area update procedure based on the broadcast TAC and PLMN ID when it moves out of the registration area.

Editor’s Note: Two possible options: (1) soft-switch broadcasting a list of TACs per cell and (2) hard-switch based on a single TAC per cell are currently considered in NR-NTN. The same solution as NR-NTN can be reused for IoT-NTN, if applicable

#### 7.3.1.2 Using ephemeris information and UE location information

Ephemeris information and UE location information can be used to help UEs perform measurement and cell selection/reselection, in addition to PCI and frequency information included in the broadcast system information [3] [10].

Editor’s Note: Provisioning of satellite ephemeris data and other information using System Information (SI) message for IoT-NTN is FFS.

#### 7.3.1.3 Enhancements to UE mobility procedure

As the challenges for NR-NTN and IoT-NTN with regards to mobility are similar, Idle Mode UE mobility procedures that are defined for NR-NTN can be reused for IoT-NTN [3] [10].

Editor’s Note: The impact of eDRX cycle on cell reselection procedure in IoT-NTN needs further discussion.

### 7.3.2 Connected mode mobility enhancements

Similar to NR-NTN [3], for LEO NTN, mobility management procedures should take satellite movement into account, while for GEO NTN, the large propagation delay needs to be accommodated.

#### 7.3.2.1 Connected Mode Mobility for NB-IoT NTN

There are no Connected Mode mobility procedures defined for NB-IoT. When an NB-IoT UE goes out of service coverage of the source cell, it experiences a Radio Link Failure (RLF). This triggers the UE to move to Idle mode, where it reselects to a new target cell and establishes an RRC connection with the target cell. RLF-based NB-IoT mobility is reused for mobility in NB-IoT based IoT-NTN. This type of Rel-16 RLF-based NB-IoT mobility is used as a baseline for mobility in NB-IoT over NTN [10].

#### 7.3.2.2 Connected Mode Mobility for eMTC NTN

Challenges in connected mode mobility for eMTC based NTN are similar to the connected mode mobility issues in NR-NTN. These include (1) high latency associated with handover signalling, (2) measurement validity, (3) frequent handovers, (4) dynamic neighbour cell list, (4) handover of a large number of UEs and (5) impact of propagation delay difference in measurements [3] [10].

Editor’s Note: Agreements regarding handover (including Conditional Handover) for NR-NTN, will be discussed for possible adoption in eMTC based IoT-NTN, if beneficial.

--- End of text proposal (Section 7) ---

--- Start of text proposal (Section B.2) ---

## B.2 Performance targets for evaluation purposes

Based on RAN2#105 conclusion on contribution R2-1901404 and SA1 specification requirements, the Non-Terrestrial network target performances per usage scenario for IoT connectivity (low power wide area service capability) was recommended in TR 38.821 as shown in Table B.2-1:

Table B.2-1: Non-Terrestrial network target performances per usage scenarios [source: TR 38.821]

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Usage scenarios** | **Experience data rate (Note 1)** | **Overall UE density per km2****(Note 2)** | **Activity factor (Note 1)** | **Max UE speed** | **Environment** | **UE categories** | **Sources** |
| DL | UL |
| IoT connectivity (low power wide area service capability) | 2 kbps | 10 kbps | 400 | 1,00% | 0 km/h | Extreme coverage | IoT | **Device density**: from R2-1901404 |6]**Data rate and activity factor**: derived from Rel-13 TR 45.820 [4] Annex E.2 "Traffic models for Cellular IoT" |

NOTE 1: As defined in TS 22.261 [5]

NOTE 2: The Overall UE density per km2 represents a peak value over a 40 km cell diameter. The actual value that can be achieved with a satellite will depend on the beam diameter.

Note 3: The user densities for the use case of moving UEs with max UE speed of 120 km/h can be further discussed, if needed.

--- End of text proposal (Section B.2) ---

# 3 Conclusion

In this contribution, we provided Text Proposals for inclusion in TR 36.763 "Study on Narrow-Band Internet of Things (NB-IoT) / enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN)" (Release 17) as captured in RAN2#112-e Chairman Report in A.I. 9.2.1 and 9.2.2.

# 4 References

1. R2-2101455: MediaTek, Eutelsat, TR 36.763 "Study on Narrow-Band Internet of Things (NB-IoT) / enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN) (Release 17)", RAN2#113e January 2021
2. RP-202689: New Study WID on NB-IoT/eTMC support for NTN