3GPP TSG RAN WG2 Meeting #113e Draft R2- 2102502

January 25th – February 5th, 2021

**Source:** Eutelsat, MediaTek

**Title:** Text proposal for TR 36.763 capturing R2#113e agreements

**Agenda Item:** 9.2.1

**Document for:** Discussion and decision

# Introduction

This document contains Text Proposals for TR 36.763 based on agreements in A.I. 9.2.2 and 9.2.3 at RAN2#113-e 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) [R1].

TPs are based on agreement as captured in RAN2#113-eChairman Report on:

- User plane enhancements

- Control plane enhancements

# Text Proposal for TR 36.763

Note: The revision marks used in this document are comparing to endorsed TP in R2-2102492 [R2]

--- Start of text proposal (Sections 2-3) ---

# 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 TR38.821 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)"

[11] 3GPP TS 36.304: "Evolved Universal Terrestrial Radio Access (E-UTRA); UE Procedures in Idle Mode (Release 16)"

[12] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification (Release 16)"

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**Availability:** % of time during which the RAN is available for the targeted communication. Unavailable communication for shorter period than [Y] ms shall not be counted. The RAN may contain several access network components among which an NTN to achieve multi-connectivity or link aggregation.

**Feeder link:** Wireless link between NTN Gateway and satellite

**Geostationary Earth orbit:** Circular orbit at 35,786 km above the Earth's equator and following the direction of the Earth's rotation. An object in such an orbit has an orbital period equal to the Earth's rotational period and thus appears motionless, at a fixed position in the sky, to ground observers.

**Low Earth Orbit:** Orbit around the Earth with an altitude between 300 km, and 1500 km.

**Medium Earth Orbit:** region of space around the Earth above low Earth orbit and below geostationary Earth Orbit.

**Minimum Elevation angle**: minimum angle under which the satellite or UAS platform can be seen by a terminal.

**Mobile Services:** a radio-communication service between mobile and land stations, or between mobile stations

**Mobile Satellite Services:** A radio-communication service between mobile earth stations and one or more space stations, or between space stations used by this service; or between mobile earth stations by means of one or more space stations

**Non-Geostationary Satellites:** Satellites (LEO and MEO) orbiting around the Earth with a period that varies approximately between 1.5 hour and 10 hours. It is necessary to have a constellation of several Non-Geostationary satellites associated with handover mechanisms to ensure a service continuity.

**Non-terrestrial networks:** Networks, or segments of networks, using an airborne or space-borne vehicle to embark a transmission equipment relay node or base station.

**NTN-gateway:** an earth station or gateway is located at the surface of Earth, and providing sufficient RF power and RF sensitivity for accessing to the satellite. NTN Gateway is a transport network layer (TNL) node.

**On Board processing:** digital processing carried out on uplink RF signals aboard a satellite or an aerial.

**On board NTN eNB**: eNB implemented in the regenerative payload on board a satellite.

**On ground NTN eNB**: eNB of a transparent satellite payload implemented on ground.

**One-way latency:** time required to propagate through a telecommunication system from a terminal to the public data network or from the public data network to the terminal. This is especially used for voice and video conference applications.

**Regenerative payload:** payload that transforms and amplifies an uplink RF signal before transmitting it on the downlink. The transformation of the signal refers to digital processing that may include demodulation, decoding, re-encoding, re-modulation and/or filtering.

**Round Trip Delay:** time required for a signal to travel from a terminal to the sat-gateway or from the sat-gateway to the terminal and back. This is especially used for web-based applications.

**Satellite:** a space-borne vehicle embarking a bent pipe payload or a regenerative payload telecommunication transmitter, placed into Low-Earth Orbit (LEO), Medium-Earth Orbit (MEO), or Geostationary Earth Orbit (GEO).

**Satellite beam:** A beam generated by an antenna on-board a satellite

**Service link:** Radio link between satellite and UE

**Transparent payload:** payload that changes the frequency carrier of the uplink RF signal, filters and amplifies it before transmitting it on the downlink

**User Connectivity:** capability to establish and maintain data / voice / video transfer between networks and Terminals

**User Throughput:** data rate provided to a terminal

## 3.2 Symbols

Void

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

CHO Conditional Handover

ECEF Earth-Centered, Earth-Fixed

EIRP Equivalent Isotropic Radiated Power

GEO Geostationary Earth Orbiting

eNB 4G Node B

GW Gateway

LEO Low Earth Orbiting

Mbps Mega bit per second

MEO Medium Earth Orbiting

MS Mobile Services

MSS Mobile Satellite Services

NGEO Non-Geostationary Earth Orbiting

NTN Non-Terrestrial Network

RAN Radio Access Network

RTD Round Trip Delay

SNR Signal-to-Noise Ratio

TA Tracking Area

TAC Tracking Area Code

TAU Tracking Area Update

TLE Two-Line Element

UAS Unmanned Aircraft System

UE User Equipment

--- End of text proposal (Sections 2-3) ---

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

5 IoT NTN Architecture and Capabilities

5.1 IoT NTN Architecture

IoT NTN connectivity via EPC is supported.

IoT NTN connectivity via 5GC is assumed.

Editor’s Note: RAN2 has requested feedback to 3GPP RAN3 and SA2 on the RAN2 assumption about the support for IoT NTN connectivity via both EPC and 5GC in R2-2102501.

5.2 IoT NTN UE Capabilities

GNSS capability in the UE is taken as a working assumption in this study for both NB-IoT and eMTC devices.

 Editor’s Note: UE can estimate and pre-compensate timing and frequency offset with sufficient accuracy for UL transmission - FFS pending RAN1 decision.

Simultaneous GNSS and NTN NB-IoT/eMTC operation is not assumed.

## 5.3 IoT NTN Features

It is assumed that all cellular IoT features specified up to Rel-16 are supported for IoT NTN.

Editor’s Note: the above assumption has been taken on a RAN2 perspective, and may be revisited on a case by case basis when/if problems are found.

It is assumed that both NB-IoT multi-carrier operation and NB-IoT single-carrier operation are supported as a baseline.

Editor’s Note: the above assumption has been taken on a RAN2 perspective.

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

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

# 7 Radio Protocol Issues and Solutions

## 7.1 Requirements and key issues

### 7.1.1 Delay

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: 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 2: 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 scenario.NOTE 3: 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 RTT and delay difference constraints

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

## 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 transmitted. If more than a certain number of preambles have been transmitted with no valid response during the RA Response window, a random access problem is indicated to upper layers.

In NTN the propagation delay is much larger and therefore, RAR message cannot be received by the UE within the time interval specified for terrestrial communications. Therefore, the starting time of RA Response window should be modified to support IoT NTN.

*Solution Overview*

Similar to NR NTN [3], the offset can be adjusted to delay the start of the RA Response window for IoT NTN [10]. If the start of the ra-ResponseWindow is accurately compensated and no extension of repetition is required, 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. UL HARQ RTT Timer is the same as DL HARQ RTT Timer, just for the uplink. If HARQ is supported by IoT NTN, the handling of DL 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 DL HARQ RTT Timer and UL HARQ RTT Timer can be reused as a baseline 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 or after 8~~ 7 NPRACH opportunities for NB-IoT [7] and initiate a SR. For GEO systems the value range may not be sufficient because of the large RTT.

*Solution Overview*

The *sr-ProhibitTimer* will be modified for including larger values to support IoT NTN. Alignment to NR NTN can be considered.

#### 7.2.1.4 HARQ

Editor’s Note: This section will be updated based on further agreements on HARQ, e.g., whether 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 accurately.

In non-terrestrial networks the drawback of this procedure is that it would take at least 2 round-trip times from data arriving in the buffer at the UE side until it can be properly scheduled with resources that would fit the data. Due to the large propagation delays this may become prohibitively large. 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 NB-IoT over NTN as latency is not a critical performance requirement for IoT devices [10].

Editor’s Note: UL scheduling enhancements for delay reduction might be needed for LTE-M UEs over NTN.

### 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]. Large propagation delay might have impacts on *t-Reordering* timer.

*Solution Overview*

The value range of the RLC *t-Reordering* timer will be extended to support 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 RTT, 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 7.3.1.1-2.



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 (i.e. earth-fixes TA similar to NR NTN). 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 LEO with moving beams

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.

The two signalling options to update the broadcast TAC for IoT NTN are described as follows:

**(1) "Hard switch" option:**

One cell broadcast only one TAC per PLMN. The new TAC replaces the old TAC and there may be some fluctuation at the border area. As shown in Figure 7.3.1.1-4, the UE will see its TAC changing like TAC-2 -> TAC-1 -> TAC-2 from T1 to T3.



Figure 7.3.1.1-4: TAC fluctuation at the border area

**(2) "Soft switch" option:**

One cell can broadcast more than one TACs per PLMN. The cell adds the new TAC in its system information in addition to the old one and removes the old TAC a bit later. If there is a chain of Tracking Areas, the TA list adds one TA more and removes one old TAC while the cell sweeps the ground. This also reduces the amount of TAUs for UEs that happen to be located at the border area. However, for the "soft switch" option, the more TACs a cell broadcast, the heavier paging load it experiences, which usually leads to a significant imbalance distribution of paging load among cells. Thus, there is a trade-off between paging load and balancing the fluctuation of actual TA area enabled by the soft switch to be considered in network planning and implementation.

Editor’s Note: RAN2 will wait for progress in NR NTN for possible updates, if applicable to IoT NTN.

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

Satellite assistance (e.g. Ephemeris information) and UE location information can be used to help UEs in IoT NTN 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.

Editor’s Note: RAN2 will wait for RAN1 progress about the details of satellite ephemeris information.

#### 7.3.1.3 Enhancements to UE Idle mode mobility

Cell selection/reselection mechanisms specified for NB-IoT/eMTC [11] will be reused as a baseline. Enhancements introduced for cell selection/re-selection mechanism in NR NTN [3] [10] will be considered if applicable to IoT NTN.

### 7.3.2 Connected mode mobility enhancements

#### 7.3.2.1 General

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.

#### 7.3.2.2 Connected Mode Mobility for NB-IoT in 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 perform RRC connection re-establishment.

Rel-16 RLF-based NB-IoT mobility is used as a baseline for mobility in NB-IoT over NTN. Rel-17 RLF enhancements in NB-IoT can be considered in NB-IoT over NTN, if applicable. Further enhancements on RLF-based mobility can be considered, e.g. by using satellite assistance (ephemeris) information.

#### 7.3.2.3 Connected Mode Mobility for eMTC in 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].

Conditional Handover can be used for both the moving cell and the fixed cell scenarios. The CHO procedure and execution conditions as defined in Rel-16 are taken as the baseline, with the following considerations:

- The existing measurement framework for CHO (e.g. measurement configuration, execution) is the baseline.

- The existing measurement criteria and events applicable to eMTC can be used for IoT NTN. Support for new measurements types would need justification, but is not precluded, e.g. for enhanced coverage.

- Time or timer based and location based CHO triggering event, in combination with the existing Rel-16 CHO measurement based event, can be introduced for both moving cell and fixed cell scenarios. Support for new triggering events is not precluded.

NOTE 1: CHO for IoT NTN does not apply for E-UTRA connected to 5GC (a similar limitation applies in Rel-16).

### 7.3.3 Paging Capacity

The paging capacity and the impact on the size of the Tracking Area are evaluated considering the target IoT NTN device density captured in Annex B.2.

Editor’s Note: Paging capacity is evaluated using the methodology captured in TR 38.821 as the baseline.

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

# 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#113-e Chairman Report in A.I. 9.2.2 and 9.2.3.

# 4 References

[R1] RP-202689: SID "Study on NB-IoT/eMTC support for Non-Terrestrial Networks", RAN#90e Dec 2020

[R2] R2-2102492: Eutelsat, MediaTek, "Text proposal for TR 36.763 related to RAN2", RAN2#113e Jan-Feb 2021