**3GPP TSG RAN WG1 Meeting #106bis-e R1-21xxxxx**

**e-Meeting, October 11th – October 19th, 2021**

Agenda Item: 8.15 - NB-IoT/eMTC support for Non-Terrestrial Network

Source: WI rapporteur (MediaTek)

Title: 3GPP TSG-RAN WG1 Agreements for Release-17 IoT NTN (post RAN1#106-bis-e)

Document for: Information

# Introduction

This document lists the RAN1 agreements in NB-IoT/eMTC support for Non-Terrestrial Network Work Item up to and including RAN1#106bis-e.

The WI objective from the Rel-17 IoT NTN WID is inserted below for convenience.

The moderator summary and spreadsheet for Rel-17 RRC parameters for IoT NTN were provided in R1-2110628 and R1-2110629 respectively. Feature leads for 8.15.1 and 8.15.2 are referenced in Section 5. The Technical Report TR 36.763 for Rel-17 IoT NTN is also referenced in Section 5.

# WID Objective

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| The objective of this Work Item is to specify support of NB-IoT and eMTC over NTN. Work on both NB-IoT and eMTC will start in August 2021 meetings.Enhancements shall be specified as described hereafter with the following assumptions:* Standalone deployment for NB-IoT / eMTC (i.e. operating in carrier(s) used only for NB-IoT NTN (resp. eMTC NTN)) for support in Rel-17 timeframe will be prioritized.
* GNSS capability in the UE is taken as a working assumption 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. Simultaneous GNSS and NTN NB-IoT/eMTC operation is not assumed.
* NB-IoT/eMTC design for terrestrial networks shall be reused as much as possible.
* Transparent payload

RAN1 ObjectivesSpecify the following time and frequency synchronization enhancements, using NR\_NTN\_solutions WI agreements as baseline, according to Section 8 in TR 36.763: * UE pre-compensation including ephemeris format (orbital / Position -Velocity)
* UE pre-compensation for UL synchronization in RRC\_IDLE and RRC\_CONNECTED states based at least on its GNSS-acquired position and the serving satellite ephemeris
* Timing advance formula (granularity of the timing advance may be different)
* Combination of Open (i.e. UE autonomous TA estimation, and common TA estimation) and Closed TA (i.e., received TA commands) control loops in RRC\_CONNECTED state

Agreements on the above are up to the decision in NR\_NTN\_Solutions WI and will be used for IoT NTN with minimum changes, if any. Specify the following time and frequency synchronization enhancements that are not covered by NR\_NTN\_Solutions WI agreements, according to Section 8 in TR 36.763:* Long PUSCH and PRACH Transmission enhancements: segmented UE pre-compensations, new UL gaps and/or implementation solutions, time units and duration of segments.
* Validity timer for UL synchronization: satellite ephemeris, and potentially other aspects
* DL synchronization enhancements: A single solution will be selected between: new channel raster, (part of) ARFCN-indication-in-MIB.
* GNSS Measurements: Validity of a GNSS position fix and details of acquiring a GNSS position fix, duration of validity, in RRC CONNECTED mode for sporadic short transmission

Specify the following IoT NTN specific timing relationships enhancements according to Section 8 in TR 36.763:* Timing relationships for NB-IoT / eMTC: as listed in Section 6.6.3 in TR 36.763
* UL scheduling for FDD-HD: Use of UE-specific TA and/or K\_offset to avoid UL-DL collisions in FDD-HD
* Signalling aspects in UE-specific TA maintenance and reporting, techniques to reduce the signalling load and determination of the UE-specific TA.
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## Enhancements to time and frequency synchronization

Agreement:

The following agreements from NR NTN are re-used for IoT NTN as working assumption.

1. The Doppler shift over the feeder link and any transponder frequency error for both Downlink and Uplink is compensated by the GW and satellite-payload without any specification impacts in Release 17.
2. The orbital propagator model to be used at UE side can be left to implementation
3. Timing Advance formula can be transposed to IoT-NTN with Ts used instead of Tc

The Timing Advance applied by an NR NTN UE in RRC\_IDLE/INACTIVE and RRC\_CONNECTED is given by:

$$T\_{TA}=\left(N\_{TA}+N\_{TA,UE-specific}+N\_{TA,common}+N\_{TA,offset}\right)×T\_{s}$$

Where:

* $N\_{TA}$  is defined as 0 for PRACH and updated based on TA Command field in msg2/msgB and MAC CE TA command.
	+ FFS: details of NTA update/accumulation.
* $N\_{TA,UE-specific}$  is UE self-estimated TA to pre-compensate for the service link delay.
* $N\_{TA,common}$ is network-controlled common TA, and may include any timing offset considered necessary by the network.
* $N\_{TA,common}$ with value of 0 is supported.
	+ FFS:  details of signaling including granularity.
* $N\_{TA,offset}$ is a fixed offset used to calculate the timing advance.

Note-1: Definition of $N\_{TA}$ is different from that in RAN1#103-e agreement in NR NTN WI.

Note-2: UE might not assume that the RTT between UE and gNB is equal to the calculated TA for Msg1/Msg A.

Note-3: $N\_{TA,common}$ is the common timing offset X as agreed in RAN1 #103-e in NR NTN WI.

1. Support the delivery of ephemeris information using both ephemeris formats, i.e., state vectors and orbital elements
* Set 1: Satellite position and velocity state vectors (position/velocity)
	+ Position X,Y,Z in ECEF (m)
	+ Velocity VX,VY,VZ in ECEF (m/s)
* Set 2: Parameters in orbital parameter ephemeris format
	+ Semi-major axis α [m]
	+ Eccentricity e
	+ Argument of periapsis ω [rad]
	+ Longitude of ascending node Ω [rad]
	+ Inclination i [rad]
	+ Mean anomaly M [rad] at epoch time to
	+ FFS: Whether pre-provisioned ephemeris based on orbital elements can be used as reference. Thereby, only delta corrections can be broadcast in order to reduce the overhead
1. For TA update in RRC\_CONNECTED state, combination of both open (i.e. UE autonomous TA estimation, and common TA estimation) and closed (i.e., received TA commands) control loops shall be supported for IoT-NTN

Agreement:

The following agreement from NR NTN are re-used for IoT NTN as working assumption

1. In Rel-17 IoT-NTN, at least support UE which can compute timing advance and frequency adjustment for serving link based on its GNSS position and serving satellite ephemeris signalled by the network and apply corresponding timing advance and frequency adjustment in RRC\_IDLE and RRC\_CONNECTED modes
2. Serving satellite ephemeris Epoch time is implicitly known as a reference time defined by the starting time of a DL slot and/or frame.

FFS: Whether this starting time is given by predefined rule or it is indicated by the Network

Agreement:

For sporadic short transmission, UE in RRC\_CONNECTED should go back to idle mode and re-acquire a GNSS position fix if GNSS becomes outdated.

Agreement:

* Satellite ephemeris read on SIB are valid for the duration of sporadic short transmission in RRC\_CONNECTED.
* Common TA parameters if indicated and read on SIB are valid for the duration of sporadic short transmission in RRC\_CONNECTED.
* Note: The duration of the short transmission is not longer than the “validity timer for UL synchronization” referred to in the WID objective (but which still needs further discussion for specifying further details)

Agreement:

The validity timer of UL synchronization is configured by the network

* FFS: Whether a single validity timer or separate validity timers are used for satellite ephemeris and common TA parameters

Agreement:

UE in RRC\_IDLE reads the satellite ephemeris on SIB and the common TA parameters if indicated on SIB and (re-)start the validity timer(s) for UL synchronization before moving to RRC\_CONNECTED.

* FFS: Details of the precise (re-)start time for the validity timer for UL synchronization to ensure a common understanding between gNB and UE.
* Other signaling details for validity timer are up to RAN2

Agreement:

Duration of UL transmission segment for UE pre-compensation for PRACH transmission is a number of RACH repetition units configured by the network

* For NB-IoT, repetition unit is P symbol groups.
* For eMTC, repetition unit is one preamble including guard period.
* FFS: Configuration details

Agreement:

Duration of UL transmission segment for UE pre-compensation for PUSCH transmission is a number of PUSCH repetition units configured by the network

* For NB-IoT, repetition unit is $M\_{identical}^{NPUSCH}×N\_{slot}^{UL}×T\_{slot}$
* For eMTC, repetition unit is $N\_{slot}^{UL}×T\_{slot}$ for sub-PRB allocation, where Tslot = 0.5 ms. For full-PRB allocation, repetition unit is one subframe.
* NOTE1: $M\_{identical}^{NPUSCH}, N\_{slot}^{UL}, T\_{slot}$ are defined in TS 36.211 10.1.2.3 and 10.1.3.6 for NB-IoT
* NOTE2: $M\_{symb}^{UL}, M\_{slot}^{UL}$M\_^UL\_slot is defined in TS 36.211, 5.2.3A for eMTC
* FFS: RAN1 to further discuss valid and invalid subframes
* FFS: Configuration details

Agreement:

For NB-IoT, if a mapping to Nslots slots or a repetition of the mapping in an UL transmission segment for UE pre-compensation for NPUSCH transmission contains a resource element which overlaps with any configured NPRACH resource, the NPUSCH transmission in overlapped Nslots slots is postponed until the next Nslots slots not overlapping with any configured NPRACH resource.

* NOTE: Nslots is defined in TS 36.211, 10.1.3.6

Agreement:

The UL transmission segment duration is configured by the network

* FFS: Details of the configuration signalling.

Agreement:

* For NB-IoT NTN, the network configures one of K values for the UL transmission segment duration of each PRACH preamble format in a k-bit field, where the size of the k-bit field and the number of K candidate values depend on the preamble format.
* Format 0 and format 1: 3-bit field, K=6 candidate values 2.4.(TCP+TSEQ), 4.4.(TCP+TSEQ), 8.4.(TCP+TSEQ), 16.4.(TCP+TSEQ), 32.4.(TCP+TSEQ), 64.4.(TCP+TSEQ)
* Format 2:  2-bit field, K=4 candidate values 2.6.(TCP+TSEQ), 4.6.(TCP+TSEQ), 8.6.(TCP+TSEQ), 16.6.(TCP+TSEQ)
* FFS: Down scoping of K candidate values, size of k-bit field
* FFS: Whether the same segment duration can be used for all preambles within a preamble format

Agreement:

For eMTC, the network configures one of K values for the UL transmission segment duration of PRACH in a k-bit field.

* FFS: K candidate values, size of k-bit field

Agreement:

* For NB-IoT/eMTC NTN, the network configures one of K candidate values for the UL transmission segment duration of NPUSCH/PUSCH in a k-bit field.
	+ For NB-IoT, maximum 3-bit field with a maximum number of K=8 candidate values 2 ms, 4 ms, 8 ms, 16 ms, 32 ms, 64 ms, 128 ms, 256 ms
* FFS: Down scoping of K candidate values, size of k-bit field

Agreement:

* The UL transmission segment duration is provided by UE-specific RRC signalling or by signalling in SIB.
* NOTE: the values of UL transmission segment duration for NB-IoT can be different to those for eMTC

## Timing relationship enhancements

Agreement:

For NB-IoT, on receiving UL grant on DCI format N0 in subframe n, NPUSCH Format 1 is transmitted with a delay of Koffset as compared to transmission as per current specification.

Agreement:

For NB-IoT, on receiving a NPDSCH with a RAR message that ends in subframe n, the corresponding Msg3 is transmitted on NPUSCH format 1, with a delay of Koffset as compared to transmission as per current specification.

Agreement:

For NB-IoT, a UE upon detection of a NPDSCH transmission for which it should provide an ACK/NACK feedback, shall transmit the HARQ ACK/NACK with a delay of Koffset as compared to transmission as per current specification.

Agreement:

For NB-IoT, on receiving a timing advance command ending in DL subframe n, the corresponding adjustment of the uplink transmission timing by the received time advance shall be delayed by Koffset as compared to current specification.

Agreement:

For eMTC, on receiving an UL grant via MPDCCH that ends in DL subframe n, PUSCH is transmitted with a delay of Koffset as compared to transmission as per current specification.

Agreement:

For eMTC, on receiving a RAR in a PDSCH that ends in subframe n, PUSCH for Msg3 is transmitted with a delay of Koffset as compared to transmission as per current specification.

Agreement:

For eMTC, when an MPDCCH ending in subframe n activates UL SPS, the time of the first subframe in which the UE is allowed to transmit SPS-PUSCH is delayed by Koffset as compared to transmission per current specification.

Agreement:

For eMTC, on reception of a PDSCH ending in subframe n, the corresponding HARQ-ACK feedback on PUCCH is transmitted with a delay of Koffset as compared to transmission as per current specification.

Agreement:

For eMTC, the ending time for DL physical resources forming a CSI reference resource set is advanced by Koffset as compared to current specification.

Agreement:

For eMTC, for an MPDCCH received in subframe n that triggers aperiodic SRS transmission, SRS is transmitted with a delay of Koffset as compared to transmission as per current specification.

Agreement:

For eMTC, on receiving a timing advance command ending in subframe n, the corresponding adjustment of the uplink transmission timing by the received time advance shall be delayed by Koffset as compared to current specification.

Agreement:

For IoT NTN, support cell-specific Koffset configuration for use during initial access.

Agreement:

For IoT NTN, support the use of UE-specific Koffset in CONNECTED mode.

Agreement:

UE-specific TA reporting is supported in IoT-NTN

* FFS: Detailed contents of report

Conclusion:

In IoT NTN the initialisation of generators for scrambling codes for UL channels and DM-RS shall use the subframe number of the UL channel or UL signal that is indicated by the Koffset-modified timing relationship.

NOTE: In the view of RAN1, this does not necessarily involve a specification change.

Conclusion:

For IoT NTN, no modifications are needed for the calculation in NR NTN for estimate of UE-eNB RTT.

## Others

No TDoc treated

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## Enhancements to time and frequency synchronization

Agreement:

The validity timer for UL synchronization is started/restarted with configured timer validity duration at the epoch time of the assistance information (i.e. serving satellite ephemeris data).

* FFS: Precise definition of epoch time taking into account SIB repetitions

Agreement:

A single validity duration for both serving satellite ephemeris and common TA related parameters is defined at least if serving satellite ephemeris and common TA parameters are signalled in the same SIB message.

Agreement:

Configuration of UL transmission segment is indicated on SIB at least for initial access

* FFS via UE-specific RRC signalling in RRC\_CONNECTED.

Agreement:

For eMTC PUSCH, a 3-bit field to indicate K=8 values for the uplink transmission segment duration:

* Full-PRB allocation (unit: subframes): 2 4 8 16 32 64 128 256
* Sub-PRB allocation (unit: resource units): 1 2 4 8 16 32 64 128

Agreement:

For eMTC, a 3-bit field is defined in the SIB to indicate the following K=8 values for the uplink transmission segment duration of PRACH:

(TCP+TSEQ+TGP), 2\*(TCP+TSEQ+TGP), 4\*(TCP+TSEQ+TGP), 8\*(TCP+TSEQ+TGP), 16\*(TCP+TSEQ+TGP), 32\*(TCP+TSEQ+TGP), 64\*(TCP+TSEQ+TGP), 128\*(TCP+TSEQ+TGP)

Agreement:

For eMTC, the same value is used for segment durations for all PRACH preambles

Agreement:

For NB-IOT, the same value is used for segment durations for all NPRACH preambles for a particular NPRACH format

Agreement:

In eMTC/NB-IoT, NTA update based on TA Command field in msg2 and MAC CE TA command is used for UL timing alignment correction as follows:

* No extension on TAC 11-bit field in Random Access Response
* When TAC (TA) in Msg2 is received, UE first adjustment and NTA is adjusted as follows: NTA,new = TA ×16, where TA is the timing advance command in msg2.
* When TACs ($T\_{A})$ provided within the MAC CE is received, $N\_{TA}$ is updated as follows:
	+ $N\_{TA\\_new}=N\_{TA\\_old}+\left(T\_{A}-31\right).16$ ,
* Where TA is the TAC field received in MAC CE command.

Agreement:

RAN1 has discussed the following aspects and leaves it up to RAN2 to specify UE behaviour related to expiry of UL synchronization validity timer and determine which of the following aspects are to be specified:

* Mechanisms for UE to declare loss of UL synchronization including mechanisms for UL synchronization recovery procedure when UL synchronization is lost if UL synchronization validity timer expires in RRC\_CONNECTED
	+ It is up to RAN2 to specify this new behaviour for connected UE within RLF set of procedures or a new procedure for re-acquiring satellite ephemeris
	+ Mechanism for UL synchronization includes re-acquiring the satellite ephemeris and common TA parameters if indicated on SIB
	+ A new clause of RLF for loss of UL synchronization if validity timer for UL synchronization expires assuming a new re-interpretation of RLF set of procedures is specified for recovery of UL synchronization with re-acquisition of satellite ephemeris and common TA parameters if indicated
	+ Potential additional RACH after re-acquisition of satellite ephemeris and common TA parameters if indicated for the UL synchronization recovery procedure in case of potential residual TA error.
* If validity timer for UL synchronization expires and no UL synchronization recovery mechanisms specified as above, UE behaviour shall declare RLF and go into idle mode autonomously to re-acquire ephemeris SIB. UE will then need to re-access the cell via Random Access procedure.
* UE signalling to indicate the validity timer for UL synchronization is about to expire

## Timing relationship enhancements

Agreement:

In IoT NTN, for a random access procedure initiated by a N/MPDCCH order, the UE shall delay the transmission of the random access preamble by *Koffset* as compared to the current specification.

Agreement:

For IoT NTN, with respect to the granularity, configuration, indication and update of K\_Offset, the mechanisms concluded in NR-NTN shall be taken as baseline.

Agreement:

For eMTC in IoT NTN, if the UE determines that a preamble retransmission is necessary, the choice of a suitable preamble retransmission subframe shall be delayed by Koffset as compared to current specifications.

Agreement:

For NB-IoT, if the UE has initiated an NPUSCH transmission using pre-configured uplink resources ending in subframe n, the UE shall start or restart to monitor the NPDCCH from DL subframe n+4+K\_mac (where K\_mac is defined as in NR-NTN).

Agreement:

For eMTC, if the UE has initiated an PUSCH transmission using pre-configured uplink resources ending in subframe n, the UE shall start or restart to monitor the MPDCCH from DL subframe n+4+K\_mac (where K\_mac is defined as in NR-NTN).

Agreement:

Support PUR at least for GEO-based IoT NTN in Rel-17

FFS: for NGSO-based IoT NTN.

Agreement:

NPDCCH monitoring restrictions have been identified for further checking to see if changes for NB-IoT need to be made for the following cases:

* case 1: MTBG NPUSCH
* case 2: 2 NPUSCH HARQ processes scheduled
* case 3: long single NPUSCH when MTBG or 2HARQ configured
* case 4: single NPUSCH scheduled by DCI format N0 or RAR
* case 5: NPUSCH format 2 in response to DCI format N1
* case 6: NPRACH in response to PDCCH order
* case 7: NPUSCH with same HARQ process when 2 HARQ configured
* case 8: subframes after NPUSCH processing
* case 9: subframes after NPUSCH carrying Msg3
* case 10: NPRACH for SR for long NPRACH transmissions
* case 11: NPRACH for SR for short NPRACH transmissions
* FFS: the changes in each case
* FFS: additional cases

## Others

No TDoc treated

# Reference

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2. RP-211456, 3GPP TR 36.763 v1.0.0: Study on Narrow-Band Internet of Things (NB-IoT) / enhanced Machine Type Communication (eMTC) support for Non-Terrestrial Networks (NTN), RAN#92-e, June 2021
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4. 3GPP TSG RAN WG1 Meeting #106bis-e RAN1 Chairman’s Notes
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8. R1-2108519, Moderator (Sony), FL summary#5 of AI 8.15.3, RAN1#106-e, August 2021
9. R1-2110628, Summary of [106bis-e-R17-RRC-IoT-NTN] IoT over NTN, RAN1#106bis-e, October 2021
10. R1-2110629, List of IoT over NTN Rel-17 RRC parameters, RAN1#106bis-e, October 2021
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