**3GPP TSG RAN WG1#106-e R1-2108312**

e-Meeting, August 16-27th, 2021

Agenda Item: **8.15.2**

Source: **Moderator (Sony)**

Title: **FL summary 1 of AI 8.15.2: Timing relationships for IoT-NTN**

Document for: **Discussion**

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# Introduction

This document is the feature lead (FL) summary of contributions for the “IoT-NTN Timing relationship enhancements” agenda item.

This is the FL document for round 1 of [106-e-NR-NB\_IoT\_eMTC-02] Email discussion/approval on timing relationship enhancements with checkpoints for agreements on August 19, 24 and 27 – Sam (Sony)

Companies are encouraged to provide their views and comments by UTC 18:00 on Tuesday Aug 17, 2021 in the relevant sections for this first round of email discussions.

# Overview of Main Issues from company contributions

At RAN#92e, a work item was approved for IoT NTN [1]. In this work item description, RAN1 is charged with specifying the following IoT NTN specific timing relationships enhancements according to Section 8 in TR 36.763 [2]:

* 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.

The contents of Section 6.6.3 of TR 36.763[2] are as follows:

The following NB-IoT timing relationships need enhancing for essential minimum functionality of IoT NTN:

- NPDCCH to NPUSCH format 1

- RAR grant to NPUSCH format 1

- NPDSCH to HARQ-ACK on NPUSCH format 2

- Timing advance command activation

- FFS: NPDCCH order to NPRACH

- FFS: Other NB-IoT timing relationships

The following eMTC timing relationships need enhancing for **essential minimum functionality of** IoT NTN:

- MPDCCH to PUSCH

- RAR grant to PUSCH

- MPDCCH to scheduled uplink SPS

- PDSCH to HARQ-ACK on PUCCH

- CSI reference resource timing

- MPDCCH to aperiodic SRS

- Timing advance command activation

- FFS: MPDCCH order to PRACH

- FFS: Other eMTC timing relationships

The enhancement based on extending the timing relationship, by e.g. Koffset, adopted in NR NTN should be the starting point for enhancement of eMTC timing relationships in IoT NTN. Details can be further discussed considering IoT NTN.

Analysis of companies’ contributions to this AI at RAN1#105-e shows that a substantial majority concentrated on the studies of the timing relationships for both NB-IoT and eMTC. A few other issues were also raised in contributions and these are also summarised in this FL document.

# Timing Relationships for NB-IoT

The following NB-IoT timing relationships need enhancing for essential minimum functionality of IoT NTN:

* NPDCCH to NPUSCH format 1
* RAR grant to NPUSCH format 1
* NPDSCH to HARQ-ACK on NPUSCH format 2
* Timing advance command activation
* FFS: NPDCCH order to NPRACH

## NPDCCH to NPUSCH format 1

This was an NB-IoT timing relationship retained for enhancement in TR36.763.

### Companies’ Observations and Proposals

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| --- | --- |
| Huawei | ***Proposal 1:*** *K\_offset is introduced to the following timing relationships for NB-IoT*   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * Timing advance command activation |
| Sony | **Proposal 2: For a DCI scheduled NPUSCH Format 1 wherein the transmission of the NPDCCH carrying the DCI finishes in subframe n, the UE is expected to start the transmission of the NPUSCH Format 1 after DL subframe n + k0 + *Koffset* and *Koffset* is an upper layer parameter.** |
| Samsung | **Proposal 1: For NB-IoT in NTN, introduce an additional delay of *k\_offset* subframes before transmission of NPUSCH format 1 scheduled by a NPDCCH with DCI format N0.** |
| MediaTek | ***Proposal 3****: For NB-IoT, on receiving UL grant on DCI format N0 in slot n, NPUSCH Format 1 is transmitted in subframe , ~~where K\_offset is equal to the UE-eNB RTT which is determined as the sum of UE’s TA and K\_mac~~* |
| OPPO | **Proposal 1: for NTN-IoT uplink scheduling, the time domain allocation should be shifted by K offset subframes.** |
| FGI, Asia Pacific Telecom, III, ITRI | 1. For NPDCCH to NPUSCH format 1, introduce K\_offset for UE to transmit NPUSCH at the end of n + k\_0 + K\_offset DL subframe, where n is for the NPDCCH reception and k\_0 is the legacy offset. |
| Ericsson | Proposal 2: Introduce cell-specific K\_offset to enhance the following timing relationships for NB-IoT NTN   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * Timing advance command activation |
| Apple | ***Proposal 4:*** *Introduce to enhance the following timing relationships for NB-IoT over NTN:*   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * NPDCCH order to NPRACH * timing advance command activation |
| InterDigital | ***Proposal-1:*** *Confirm timing relationship list requiring Koffset for essential minimum functionality for NB-IoT and eMTC in the TR 36.763.* |

### FIRST ROUND Discussion on NPDCCH to NPUSCH format 1

All 9 companies that make proposals, agree that this timing relationship should be enhanced by adding Koffset. FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

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.

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| Company | Support/Not Support | Comments |
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## RAR grant to NPUSCH format 1

This was an NB-IoT timing relationship retained for enhancement in TR36.763.

### Companies’ Observations and Proposals

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| Huawei | ***Proposal 1:*** *K\_offset is introduced to the following timing relationships for NB-IoT*   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * Timing advance command activation |
| Sony | **Proposal 3: When the UE receives a narrowband RACH response UL resource grant carried in an NPDSCH that ends in DL subframe n, it uses a scheduling delay of k0 + *Koffset* (where k0 is the Rel-16 value) to commence the transmission of the NPUSCH carrying Msg3.** |
| Samsung | **Proposal 2: For NB-IoT in NTN, introduce an additional delay of *k\_offset* subframes before transmission of NPUSCH format 1 scheduled by a RAR grant.** |
| MediaTek | ***Proposal 2****: For NB-IoT, on receiving a NPDSCH with a RAR message in slot n, message 3 is transmitted on NPUSCH format 1in subframe n+k0.* |
| FGI, Asia Pacific Telecom, III, ITRI | 1. For RAR grant to NPUSCH format 1, introduce K\_offset to transmit MSG3 at the end of n + k\_0 + K\_offset DL subframe, where the DL subframe n contains MSG2. |
| Ericsson | Proposal 2: Introduce cell-specific K\_offset to enhance the following timing relationships for NB-IoT NTN   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * Timing advance command activation |
| Apple | ***Proposal 4:*** *Introduce to enhance the following timing relationships for NB-IoT over NTN:*   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * NPDCCH order to NPRACH * timing advance command activation |
| InterDigital | ***Proposal-1:*** *Confirm timing relationship list requiring Koffset for essential minimum functionality for NB-IoT and eMTC in the TR 36.763.* |
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### FIRST ROUND Discussion on RAR grant to NPUSCH format 1

All 9 companies that make proposals, agree that this timing relationship should be enhanced by adding Koffset. FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

FL Proposal 3.2.2-1:

For NB-IoT, on receiving a NPDSCH with a RAR message in slot n, message 3 is transmitted on NPUSCH format 1, with a delay of Koffset as compared to transmission as per current specification.

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| Company | Support/Not Support | Comments |
| Intel | Support |  |
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## NPDSCH to HARQ-ACK on NPUSCH format 2

This was an NB-IoT timing relationship retained for enhancement in TR36.763.

### Companies’ Observations and Proposals

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| Huawei | ***Proposal 1:*** *K\_offset is introduced to the following timing relationships for NB-IoT*   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * Timing advance command activation |
| Sony | **Proposal 4: A UE that finishes the reception of a NPDSCH for which a HARQ-ACK/NACK needs to be fed back on NPUSCH, is expected to start the NPUSCH transmission carrying the HARQ-ACK/NACK after the end of DL subframe n+k0’-1 + *Koffset*. k0 is determined as per Rel-16.** |
| Samsung | **Proposal 3: For NB-IoT in NTN, introduce an additional delay of *k\_offset* subframes before transmission of NPUSCH format 2 scheduled by a RAR grant.** |
| MediaTek | ***Proposal 4****: For NB-IoT, on receiving DL assignment on DCI format N1 in slot n, HARQ-ACK on NPUSH Format 2 is transmitted in subframe n+K\_offset +k0, ~~where K\_offset is equal to the UE-eNB RTT which is determined as the sum of UE’s TA and K\_mac~~* |
| FGI, Asia Pacific Telecom, III, ITRI | 1. For NPDSCH to HARQ-ACK on NPUSCH format 2, introduce K\_offset to provide an ACK/NACK after the end of m + k\_0 – 1 + K\_offset DL subframe, where m is a subframe for NPDSCH reception. |
| Ericsson | Proposal 2: Introduce cell-specific K\_offset to enhance the following timing relationships for NB-IoT NTN   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * Timing advance command activation |
| Apple | ***Proposal 4:*** *Introduce to enhance the following timing relationships for NB-IoT over NTN:*   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * NPDCCH order to NPRACH * timing advance command activation |
| InterDigital | ***Proposal-1:*** *Confirm timing relationship list requiring Koffset for essential minimum functionality for NB-IoT and eMTC in the TR 36.763.* |
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### FIRST ROUND Discussion on NPDSCH to HARQ-ACK on NPUSCH format 2

All 8 companies that make proposals, agree that this timing relationship should be enhanced by adding Koffset. FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

FL Proposal 3.3.2-1:

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

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| Company | Support/Not Support | Comments |
| Intel | Support |  |
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## Timing advance command activation

This was an NB-IoT timing relationship retained for enhancement in TR36.763.

### Companies’ Observations and Proposals

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| Huawei | ***Proposal 1:*** *K\_offset is introduced to the following timing relationships for NB-IoT*   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * Timing advance command activation |
| Sony | **Proposal 6: For a TAC received up to the end of DL slot n, the TA should be applied for any UL transmissions following DL subframe n+12+*Koffset*.** |
| MediaTek | ***Proposal 5****: For a timing advance command reception ending in DL subframe n in IoT NTN,*   * *the corresponding adjustment of the uplink transmission timing shall apply from the first available NB-IoT uplink slot following the end of n+K\_offset DL subframe and the first available NB-IoT uplink slot is the first slot of a NPUSCH transmission* |
| FGI, Asia Pacific Telecom, III, ITRI | 1. For Timing advance command activation, the need for K\_offset shall be reviewed considering the first NB-IoT UL slot follows the end of a DL subframe rather than a UL subframe. 2. For Timing advance command activation, determination of the overlapped part of UL slots shall be extended from 1 UL slot to k UL slots. |
| Ericsson | Proposal 2: Introduce cell-specific K\_offset to enhance the following timing relationships for NB-IoT NTN   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * Timing advance command activation |
| Apple | ***Proposal 4:*** *Introduce to enhance the following timing relationships for NB-IoT over NTN:*   * NPDCCH to NPUSCH format 1 * RAR grant to NPUSCH format 1 * NPDSCH to HARQ-ACK on NPUSCH format 2 * NPDCCH order to NPRACH * timing advance command activation |
| InterDigital | ***Proposal-1:*** *Confirm timing relationship list requiring Koffset for essential minimum functionality for NB-IoT and eMTC in the TR 36.763.* |
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### FIRST ROUND Discussion on Timing advance command activation

All 7 companies that make proposals, agree that this timing relationship should be enhanced by adding Koffset. FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

FL Proposal 3.4.2-1:

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

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| Company | Support/Not Support | Comments |
| Intel | Support |  |
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# Timing Relationships for eMTC

The following eMTC timing relationships need enhancing for **essential minimum functionality of** IoT NTN:

* MPDCCH to PUSCH
* RAR grant to PUSCH
* MPDCCH to scheduled uplink SPS
* PDSCH to HARQ-ACK on PUCCH
* CSI reference resource timing
* MPDCCH to aperiodic SRS
* Timing advance command activation
* FFS: MPDCCH order to PRACH
* FFS: Other eMTC timing relationships

## MPDCCH to PUSCH

This was an eMTC timing relationship retained for enhancement in TR36.763.

### Companies’ Observations and Proposals

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| Sony | **Proposal 7: the UE shall upon detection on a given serving cell of a PDCCH/EPDCCH with DCI format 0/4 and/or a PHICH transmission in subframe n intended for the UE, perform a corresponding PUSCH transmission in subframe (n+kp+Koffset) according to the PDCCH/EPDCCH and PHICH information where kp = 3 if the UE is configured with higher layer parameter shortProcessingTime and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, otherwise kp = 4.** |
| OPPO | **Proposal 1: for NTN-IoT uplink scheduling, the time domain allocation should be shifted by K offset subframes.** |
| Ericsson | **Proposal 1: Introduce cell-specific K\_offset to enhance the following timing relationships for eMTC NTN**  - MPDCCH to PUSCH  - RAR grant to PUSCH  - MPDCCH to scheduled uplink SPS  - PDSCH to HARQ-ACK on PUCCH  - CSI reference resource timing  - MPDCCH to aperiodic SRS  - Timing advance command activation |
| Apple | ***Proposal 3:*** *Introduce to enhance the following timing relationships for eMTC over NTN:*   * MPDCCH to PUSCH * RAR grant to PUSCH * MPDCCH to scheduled uplink SPS * PDSCH to HARQ-ACK on PUCCH * CSI reference resource timing * MPDCCH to aperiodic SRS * timing advance command activation |
| InterDigital | ***Proposal-1:*** *Confirm timing relationship list requiring Koffset for essential minimum functionality for NB-IoT and eMTC in the TR 36.763.* |
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### FIRST ROUND Discussion on MPDCCH to PUSCH

All 5 companies that make proposals, agree that this timing relationship should be enhanced by adding Koffset. FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

FL Proposal 4.1.2-1:

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

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| Company | Support/Not Support | Comments |
| Intel | Support |  |
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## RAR grant to PUSCH

This was an eMTC timing relationship retained for enhancement in TR36.763.

### Companies’ Observations and Proposals

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| Sony | **Proposal 8: For a RAR received in a PDSCH whose last subframe is received in subframe *n*, PUSCH is transmitted in the next available subframe after subframe n + 6+ *Koffset*.** |
| Ericsson | **Proposal 1: Introduce cell-specific K\_offset to enhance the following timing relationships for eMTC NTN**  - MPDCCH to PUSCH  - RAR grant to PUSCH  - MPDCCH to scheduled uplink SPS  - PDSCH to HARQ-ACK on PUCCH  - CSI reference resource timing  - MPDCCH to aperiodic SRS  - Timing advance command activation |
| Apple | ***Proposal 3:*** *Introduce to enhance the following timing relationships for eMTC over NTN:*   * MPDCCH to PUSCH * RAR grant to PUSCH * MPDCCH to scheduled uplink SPS * PDSCH to HARQ-ACK on PUCCH * CSI reference resource timing * MPDCCH to aperiodic SRS * *timing advance command activation* |
| InterDigital | ***Proposal-1:*** *Confirm timing relationship list requiring Koffset for essential minimum functionality for NB-IoT and eMTC in the TR 36.763.* |
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### FIRST ROUND Discussion on RAR grant to PUSCH

All 4 companies that make proposals, agree that this timing relationship should be enhanced by adding Koffset. FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

FL Proposal 4.2.2-1:

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.

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| Company | Support/Not Support | Comments |
| Intel | Support |  |
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## MPDCCH to scheduled uplink SPS

This was an eMTC timing relationship retained for enhancement in TR36.763.

### Companies’ Observations and Proposals

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| --- | --- |
| Ericsson | **Proposal 1: Introduce cell-specific K\_offset to enhance the following timing relationships for eMTC NTN**  - MPDCCH to PUSCH  - RAR grant to PUSCH  - MPDCCH to scheduled uplink SPS  - PDSCH to HARQ-ACK on PUCCH  - CSI reference resource timing  - MPDCCH to aperiodic SRS  - Timing advance command activation |
| Apple | ***Proposal 3:*** *Introduce to enhance the following timing relationships for eMTC over NTN:*   * MPDCCH to PUSCH * RAR grant to PUSCH * MPDCCH to scheduled uplink SPS * PDSCH to HARQ-ACK on PUCCH * CSI reference resource timing * MPDCCH to aperiodic SRS * timing advance command activation |
| InterDigital | ***Proposal-1:*** *Confirm timing relationship list requiring Koffset for essential minimum functionality for NB-IoT and eMTC in the TR 36.763.* |
|  |  |

### FIRST ROUND Discussion on MPDCCH to scheduled uplink SPS

All 3 companies that make proposals, agree that this timing relationship should be enhanced by adding Koffset. FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

FL Proposal 4.3.2-1:

For eMTC, when an MPDCCH ending in subframe n schedules an SPS-PUSCH, the SPS-PUSCH shall be transmitted with a delay of Koffset as compared to transmission as per current specification.

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| Company | Support/Not Support | Comments |
| Intel | Support |  |
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## PDSCH to HARQ-ACK on PUCCH

This was an eMTC timing relationship retained for enhancement in TR36.763.

### Companies’ Observations and Proposals

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| --- | --- |
| Sony | **Proposal 9: For a PDSCH whose last subframe is transmitted in subframe n, HARQ-ACK on PUCCH is transmitted on subframe n + 4+*Koffset*.** |
| Ericsson | **Proposal 1: Introduce cell-specific K\_offset to enhance the following timing relationships for eMTC NTN**  - MPDCCH to PUSCH  - RAR grant to PUSCH  - MPDCCH to scheduled uplink SPS  - PDSCH to HARQ-ACK on PUCCH  - CSI reference resource timing  - MPDCCH to aperiodic SRS  - Timing advance command activation |
| Apple | ***Proposal 3:*** *Introduce to enhance the following timing relationships for eMTC over NTN:*   * MPDCCH to PUSCH * RAR grant to PUSCH * MPDCCH to scheduled uplink SPS * PDSCH to HARQ-ACK on PUCCH * CSI reference resource timing * MPDCCH to aperiodic SRS * timing advance command activation |
| InterDigital | ***Proposal-1:*** *Confirm timing relationship list requiring Koffset for essential minimum functionality for NB-IoT and eMTC in the TR 36.763.* |
|  |  |

### FIRST ROUND Discussion on PDSCH to HARQ-ACK on PUCCH

All 4 companies that make proposals, agree that this timing relationship should be enhanced by adding Koffset. FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

FL Proposal 4.4.2-1:

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.

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| Company | Support/Not Support | Comments |
| Intel | Support |  |
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## CSI reference resource timing

This was an eMTC timing relationship retained for enhancement in TR36.763.

### Companies’ Observations and Proposals

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| --- | --- |
| Sony | **Proposal 10:** **The CSI reference resource is a set of DL physical resources ending in subframe n – nCQI\_ref + *Koffset*, where in the most stringent case for timing, nCQI\_ref can be as little as 4.** |
| Ericsson | **Proposal 1: Introduce cell-specific K\_offset to enhance the following timing relationships for eMTC NTN**  - MPDCCH to PUSCH  - RAR grant to PUSCH  - MPDCCH to scheduled uplink SPS  - PDSCH to HARQ-ACK on PUCCH  - CSI reference resource timing  - MPDCCH to aperiodic SRS  - Timing advance command activation |
| Apple | **Proposal 3:** Introduce to enhance the following timing relationships for eMTC over NTN:   * MPDCCH to PUSCH * RAR grant to PUSCH * MPDCCH to scheduled uplink SPS * PDSCH to HARQ-ACK on PUCCH * CSI reference resource timing * MPDCCH to aperiodic SRS * timing advance command activation |
| InterDigital | ***Proposal-1:*** *Confirm timing relationship list requiring Koffset for essential minimum functionality for NB-IoT and eMTC in the TR 36.763.* |
|  |  |

### FIRST ROUND Discussion on CSI reference resource timing

All 4 companies that make proposals, agree that this timing relationship should be enhanced by adding Koffset. FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

FL Proposal 4.5.2-1:

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

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| --- | --- | --- |
| Company | Support/Not Support | Comments |
| Intel | Support |  |
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## MPDCCH to aperiodic SRS

This was an eMTC timing relationship retained for enhancement in TR36.763.

### Companies’ Observations and Proposals

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| --- | --- |
| Sony | **Proposal 11: For an MPDCCH transmitted on subframe ‘n’ that triggers aperiodic SRS transmission, SRS is transmitted in the first subframe that satisfies n + k + *Koffset*, k is the Rel-16 value.** |
| Ericsson | Proposal 1: Introduce cell-specific K\_offset to enhance the following timing relationships for eMTC NTN  - MPDCCH to PUSCH  - RAR grant to PUSCH  - MPDCCH to scheduled uplink SPS  - PDSCH to HARQ-ACK on PUCCH  - CSI reference resource timing  - MPDCCH to aperiodic SRS  - Timing advance command activation |
| Apple | ***Proposal 3:*** *Introduce to enhance the following timing relationships for eMTC over NTN:*   * MPDCCH to PUSCH * RAR grant to PUSCH * MPDCCH to scheduled uplink SPS * PDSCH to HARQ-ACK on PUCCH * CSI reference resource timing * MPDCCH to aperiodic SRS * timing advance command activation |
| InterDigital | ***Proposal-1:*** *Confirm timing relationship list requiring Koffset for essential minimum functionality for NB-IoT and eMTC in the TR 36.763.* |
|  |  |

### FIRST ROUND Discussion on MPDCCH to aperiodic SRS

All 4 companies that make proposals, agree that this timing relationship should be enhanced by adding Koffset. FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

FL Proposal 4.6.2-1:

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.

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| --- | --- | --- |
| Company | Support/Not Support | Comments |
| Intel | Support |  |
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## Timing advance command activation

This was an eMTC timing relationship retained for enhancement in TR36.763.

### Companies’ Observations and Proposals

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| --- | --- |
| Sony | **Proposal 12:** **For a timing advance command received on subframe n, the adjustment of uplink transmission timing is made on subframe n + 6 + *Koffset*.** |
| Ericsson | **Proposal 1: Introduce cell-specific K\_offset to enhance the following timing relationships for eMTC NTN**  - MPDCCH to PUSCH  - RAR grant to PUSCH  - MPDCCH to scheduled uplink SPS  - PDSCH to HARQ-ACK on PUCCH  - CSI reference resource timing  - MPDCCH to aperiodic SRS  - Timing advance command activation |
| Apple | ***Proposal 3:*** *Introduce to enhance the following timing relationships for eMTC over NTN:*   * MPDCCH to PUSCH * RAR grant to PUSCH * MPDCCH to scheduled uplink SPS * PDSCH to HARQ-ACK on PUCCH * CSI reference resource timing * MPDCCH to aperiodic SRS * timing advance command activation |
| InterDigital | ***Proposal-1:*** *Confirm timing relationship list requiring Koffset for essential minimum functionality for NB-IoT and eMTC in the TR 36.763.* |
|  |  |

### FIRST ROUND Discussion on Timing advance command activation

All 4 companies that make proposals, agree that this timing relationship should be enhanced by adding Koffset. FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

FL Proposal 4.7.2-1:

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.

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| Company | Support/Not Support | Comments |
| Intel | Support |  |
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# Other Timing Relationships for eMTC/NB-IoT

TR36.763 recorded FFS for some timing relationships that were discussed during the SI but for company views did not converged. Some that were discussed were:

* FFS: NPDCCH order to NPRACH
* FFS: MPDCCH order to PRACH
* FFS: Other NB-IoT/eMTC timing relationships
  + Preamble retransmission

Companies have continued to study these and other timing relationships.

## NPDCCH order to NPRACH

In Section 6.6.3 of TR 36.763, this relationship is listed as FFS. Companies have studied this.

### Companies’ Observations and Proposals

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| --- | --- |
| Sony | **Proposal 5: When a UE receives an NPDCCH ending in DL subframe n and carrying a PDCCH command for a PRACH, the UE should start NPRACH transmission at any UL subframe after DL subframe n+8+ *Koffset* in which a NPRACH resource is available.** |
| Samsung | **Proposal 4: For NB-IoT in NTN, introduce an additional delay of *k\_offset* subframes before transmission of a random access preamble when the random access procedure is initiated by a PDCCH order.** |
| FGI, Asia Pacific Telecom, III, ITRI | 1. For NPDCCH order to NPRACH, introduce K\_offset to start transmission of the random-access preamble at the end of the first DL subframe n + k\_2 + K\_offset. |
| ZTE | ***Proposal-1:*** *In NB-IoT/eMTC over NTN, introducing K\_offset should be supported to enhance the timing of PDCCH order to PRACH.* |
| Intel | Proposal 4:   * MPDCCH/NPDCCH ordered PRACH/NPRACH should be supported for NTN without blind detection at the eNB   + Alt. 1: PRACH occasion is determined at the eNB based on UE-specific TA reported by the UE   + Alt. 2: UE selects PRACH occasion based on slot offset K\_offset |
| Xiaomi | ***Proposal 1: Keep an aligned design between NTN and IoT NTN for the N/MPDCCH ordered PRACH.*** |
| InterDigital | ***Proposal-3:*** *Rely on the decisions made in the NR NTN WI for the use of Koffset for the PDCCH order to PRACH.* |
|  |  |

### FIRST ROUND Discussion on NPDCCH order to NPRACH

7 companies make proposals on timing relationship enhancement for N/MPDCCH ordered PRACH with 5 companies explicitly proposing that the timing relationship should be enhanced. Two companies, having analysed the issue feel that it not only impacts IoT NTN but also NR NTN. So they propose that the resolution of the need for and the enhancement itself of the timing relationship for N/MPDCCH ordered PRACH should be aligned between NR NTN and IoT NTN, Given that this issue was widely discussed in the SI, FL makes the following proposal and invites companies to indicate their support and comment accordingly.

FL Proposal 5.1.2-1:

For IoT NTN, adopt the solution of NR NTN as starting point for time relation enhancement of N/MPDCCH ordered PRACH.

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| --- | --- | --- |
| Company | Support/Not Support | Comments |
| Intel | Support | We support the proposal in principle. However, nothing is agreed for NR NTN for PDCCH ordered PRACH so far. So, this discussion should be delayed for IoT NTN. |
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## Preamble Retransmission

This timing relationship was briefly studied during the SI but without convergence amongst companies. 7 Companies have continued to study this.

### Companies’ Observations and Proposals

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| --- | --- |
| vivo | ***Proposal 2:*** ***For NB-IoT in NTN, not support to enhance the timing relationship of preamble retransmission*.** |
| Huawei | ***Observation 1:*** *According to the current specification, a UE can select a suitable occasion for PRACH retransmission taking into account effect of timing advanced applied at the UE.*  ***Proposal 2:*** *There is no need to enhance the timing relationship of NPRACH preamble retransmission.* |
| Samsung | **Proposal 5: The timing relationship for PRACH retransmission in NB-IoT is reused for NTN NB-IoT.** |
| CATT | **Proposal 1: For NB-IoT in NTN, timing enhancement of preamble retransmission is needed.** |
| MediaTek | ***Revised Proposal 6****: For NB-IoT in NTN, timing enhancement of preamble retransmission is needed* |
| ZTE | ***Proposal-2:*** *In NB-IoT/eMTC over NTN, enhancement on the timing of PRACH preamble retransmission is needed.* |
| Xiaomi | ***Proposal 2: Enhancement for preamble retransmission for NB-IoT/eMTC can be supported.*** |

### FIRST ROUND Discussion on Preamble Retransmission

7 companies make proposals on timing relationship enhancement for Preamble Retransmission with 4 companies explicitly proposing that the timing relationship should be enhanced. 2 companies propose that there is no need to enhance whilst one company proposes that the NR NTN solution should be adopted. CATT agues in their contribution considering NB-IoT specifications that:

if a random access response is received and the corresponding DL-SCH transport block ending in subframe does not contain a response to the transmitted preamble sequence, or if no NPDCCH scheduling random access response is received in subframe , the UE shall, if requested by higher layers, be ready to transmit a new preamble sequence no later than the NB-IoT UL slot starting 12 milliseconds after the end of subframe *n*.

In current specifications for terrestrial networks, UE retransmits preamble with TA=0 and thus 12 milliseconds are sufficient. In NTN however, the UE will retransmit the preamble with UE\_specific TA, which can be larger than 12 milliseconds. If the UE\_specific TA is larger than 12ms, this would mean that the retransmission should occur before the reception of RAR or NPDSCH in subframe n. As this is not possible, for the retransmission of preamble an offset is necessary.

Taking the above into account, and considering both NB-IoT and eMTC, FL makes the following proposal and invites companies to indicate their support and comment accordingly.

FL Proposal 5.2.2-1:

**For IoT NTN, timing enhancement of preamble retransmission is needed.**

For **IoT NTN**, if the UE determines that a preamble retransmission is necessary, the choice of a suitable preamble retransmission slot shall be delayed by Koffset as compared to current specification.

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| --- | --- | --- |
| Company | Support/Not Support | Comments |
| Intel | Support | Timing relationship for that case is specified in section 16.3.2 of TS 36.213. Based on the spec it is obvious that there is an issue for NTN. |
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## NPUSCH using PUR

### Companies’ Observations and Proposals

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| --- | --- | --- |
| FGI, Asia Pacific Telecom, III, ITRI | 1. PUR enhancement on the RAR window has been agreed in RAN2, however, no related discussion has been started in RAN1. 2. If the UE has initiated an NPUSCH transmission using pre-configured uplink resource ending in subframe n, the UE shall monitor the NPDCCH UE-specific search space in a search space window starting in subframe n + 4 + K\_RTT, where K\_RTT is an estimate of UE-eNB RTT.   Problem statement  If the UE has initiated an NPUSCH transmission using pre-configured uplink resource ending in subframe n, the UE shall monitor the NPDCCH UE-specific search space in a search space window starting in subframe n + 4 with duration given by higher layer parameter pur-SS-window-duration.  However, the configured pur-SS window may start too early that UE may not receive the corresponding NPDCCH. Note that RAN2 has an agreement related to PUR. See TR 36. 763, clause 7.2.1.7 below.   |  | | --- | | **3GPP TR 36.763** V17.0.0 (2021-06), clause 7.2.1.7  An offset can be added to the start of the pur-ResponseWindowTimer. If the start of the pur-ResponseWindowTimer is accurately compensated by UE-gNB RTT, there is no need to extend the pur-ResponseWindowTimer value range. | |
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# K\_offset Handling

Issues needing study and discussion covered in company contributions include:

* Cell or beam-specific Koffset at initial access
* Need for update of Koffset after initial access
* Updating mechanism of Koffset

## K\_offset at initial access

### Companies’ Observations and Proposals

|  |  |
| --- | --- |
| Spreadtrum | ***Proposal 1: Cell*** ***specific K\_offset configuration should be supported and used in initial access.*** |
| Samsung | **Proposal 6:** **Support cell-specific timing offset during initial access. The cell-specific timing offset is transmitted in SIB.** |
| CATT | **Proposal 3: Configure** **cell specific Koffset based on maximum UE differential delay in initial access.** |
| Nordic Semiconductor ASA | ***Proposal-2:*** *Common* , *for MSG3 scheduling is indicated in SIB1 and is determined by eNB based on (but not only) maximum UE-specific TA component in the cell.* |
| Nokia, Nokia Shanghai Bell | **Observation 1: Large complexity for IoT UE and large standardization effort are needed for IoT UE in NTN to support beam specific processing, especially considering less requirement for update of K\_offset when with short sporadic transmission.**  **Proposal 1: Beam specific processing is not introduced into LTE IoT NTN and Cell-specific K\_offset could be used for time relation in IoT NTN.** |
| OPPO | **Proposal 2: In R17 NTN-IoT, only cell-specific K offset is considered and RAN1 does not consider UE-specific K offset updating.** |
| Intel | Proposal 1:   * Support additional common slot offset K\_offset for the Timing relationships for NB-IoT / eMTC listed in Section 6.6.3 in TR 36.763   + Support at least cell-specific configuration of K\_offset;   + FFS: UE-specific configuration of K\_offset   Proposal 5:   * Consider the following options for K\_offset indication   + Alt. 1: Single K\_offset value is indicated   + Alt. 2: Two K\_offset values corresponding to service link and feeder link are indicated separately * FFS: Implicit determination of K\_offset for feeder link from Common TA (or vice versa) |
| Apple | ***Proposal 1:*** *A cell specific is broadcasted in system information.* |
| ZTE | ***Proposal 3:*** *Reusing the signalling mechanism on indication/updates of K\_offset, Kmac defined in NR-NTN should be supported for IoT-NTN.* |
| Lenovo, Motorola Mobility | ***Proposal 1: Cell specific timing offset Koffset is broadcasted in SIB.*** |
| InterDigital | ***Proposal-4:*** *Cell-specific Koffset is only considered for IoT-NTN for initial access.* |

### FIRST ROUND Discussion on K\_offset at initial access

Of the 11 companies that made proposals on K\_offset at initial access, 10 companies support using a cell-specific Koffset. The one company makes a proposal about the reuse of signalling mechanisms from NR NTN for Koffset configuration. No company argues for a beam-specific Koffset. FL makes the following proposal and encourages companies to express their views.

FL Proposal 6.1.2-1:

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

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| --- | --- | --- |
| Company | Support/Not Support | Comments |
| Intel | Support |  |
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## K\_offset after initial access

### Companies’ Observations and Proposals

|  |  |
| --- | --- |
| Spreadtrum | ***Proposal 2: Cell-specific or beam-specific K\_offset would be used after initial access in IOT NTN.*** |
| Samsung | **Proposal 7: Support cell-specific and UE-specific timing offset after initial access. Timing offset is configurable.** |
| Nordic Semiconductor ASA | ***Proposal-3:*** *In MSG4, eNB configures UE-specific that is larger than total TA.* |
| MediaTek | ***Observation 1****: For half-duplex UEs (including NB-IoT and HD eMTC), configuring K\_offset value to maximum differential TA may cause collision of DL and UL subframes and cause interruption of DL subframes.*  ***Observation 2****: For connected half-duplex UEs (including NB-IoT and HD eMTC), updating the K\_offset value based on UE-specific TA report can avoid collision issue between DL and UL subframes and interrupted DL subframe issue.* |
| OPPO | **Proposal 2: In R17 NTN-IoT, only cell-specific K offset is considered and RAN1 does not consider UE-specific K offset updating.** |
| Apple | ***Proposal 2:*** *Updating after initial access in IoT NTN is not supported.* |
| InterDigital | ***Proposal-2:*** *Support Koffset=0 configuration when worst case RTD is smaller than the maximum time offset supported for the timing relationships in NB-IoT/eMTC.*  ***Proposal-5:*** *Koffset update after initial access is supported for IoT-NTN.*  ***Proposal-6:*** *Beam-specific Koffset update after initial access is supported for IoT-NTN.* |
| Qualcomm | ***Observation 1*: UE-specific K\_offset is derived based on the UE-specific TA. As a result, the UE-specific TA is the fundamental quantity that needs to be reported (and updated) by the UE to the network, for the network to ensure causal and collision-free scheduling of UL/DL communications for half-duplex UEs.**  ***Proposal 4*: Specifiy UE-specific K\_offset(s) for IoT-NTN.**  There has been some discussion as to whether a UE-specific K\_offset is essential for IoT-NTN. In our view, it is indeed essential, since without a UE-specific K\_offset, the throughput will suffer significantly when the differential delay between the UEs in an NTN cell is high—such as in GEO-based deployments—since the cell-specific K\_offset has to cater to the worst-case, i.e., ensure that the UE with the maximum round-trip delay can be scheduled causally. |
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### FIRST ROUND Discussion on K\_offset at initial access

Of the 8 companies that made proposals on K\_offset after initial access,

* 5 companies support using a UE-specific Koffset whilst 3 companies do not
* 2 companies support beam-specific Koffset,

Beam-specific Koffset is more accurate than cell-specific Koffset for the deployment scenario of multiple beams per cell but it is the same as cell-specific Koffset for single beam per cell deployments. There is need for UE-specific TA awareness at the eNB since the differential delay per cell is likely to be quite large because of the footprint size of the beam/cell. If the UE and eNB are aware of UE-specific TA, can UE-specific Koffset be derived from UE-specific TA?

FL survey 6.1.2-1

Companies are encouraged to show their choices in order of preference with respect to these 3 options:

* Option 1: Use only cell-specific or beam-specific Koffsets after initial access
* Option 2: Allow Koffset update (fine-tuning) after initial access to:
  + Option 2a: UE-specific Koffset
  + Option 2b: beam-specific Koffset only

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| --- | --- | --- |
| Company | Options Preference Order | Comments |
| Intel | Option 2a, Option 1 | Term “beam” is not clear for NB-IoT and eMTC. For NR NTN it is clear that beam is associated with particular SSB index. For LTE multiple SSB corresponding to different beams is not supported.  Thus, it is better to discuss the meaning of “beam” for NB-IoT and eMTC if we want to use term “beam”. |
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# UE specific TA

Issues needing study and discussion covered in company contributions include:

* The need and role for UE-specific TA
* Efficient signaling/updating of UE-specific TA

### Companies’ Observations and Proposals

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| --- | --- |
| Huawei | ***Observation 2:*** *For a stationary or low speed UE, calculating UE specific TA at the network side could save the signalling overhead.*  ***Proposal 3:*** *For stationary or low speed UE, support UE reporting its location with some bias to calculate UE specific TA.*  ***Proposal 4:*** *For UE with high speed, a biased location can be reported for UE-specific K\_offset and a differential value can be reported for UE-specific K\_offset update.* |
| Qualcomm | ***Observation 1*: UE-specific K\_offset is derived based on the UE-specific TA. As a result, the UE-specific TA is the fundamental quantity that needs to be reported (and updated) by the UE to the network, for the network to ensure causal and collision-free scheduling of UL/DL communications for half-duplex UEs.**  ***Proposal 1*: A UE reports the UE-specific TA to the network when the previously reported value differs from a current value by a pre-determined threshold.**  ***Proposal 2*: The UE-specific TA is reported in an uplink semi-persistent scheduling (UL-SPS) message, such as the one used for reporting buffer status reports (BSRs) in NB-IoT.** |
| CATT | **Proposal 4: After initial access, support UE-specfic TA reporting for UL-DL timing relationships scheduling.**  **Proposal 5: On UE\_specific TA reporting, both event triggered based reporting and periodic reporting can be supported for different scenarios.**  **Proposal 6: One threshold is used for TA report triggering.**  **Proposal 7: Coarse TA range reporting with larger granularity can be supported, rather than accurate TA reporting.** |
| MediaTek | ***Observation 3****: The TA report needs to be reported by UE when its UE-specific TA has changed by half subframe duration to avoid DL-UL subframe collision issue. In LEO at 600 km orbit, a TA report every 5 seconds would be sufficient. In GEO, the TA report frequency can be much longer depending on the UE mobility.*  ***Proposal 7****: The UE shall report its UE-specifc TA to the gNB in Message 3 during initial cell access.*  ***Proposal 8****: The connected UE shall report its UE-specific TA via MAC CE.*  ***Proposal 9****: The UE-specific TA report shall be reported by connected UE when the UE-specific TA has changed by an amount not exceeding half subframe duration*  ***Proposal 10****: Support Option 1 Event triggered (i.e. autonomous decision by the UE to send the TA report) and Option 2: Network request for UE-specific TA report.* |
| OPPO | **Proposal 3: UE TA reporting is not needed if cell-specific K offset is considered.** |
| FGI, Asia Pacific Telecom, III, ITRI | 1. Deprioritize scheduling enhancement on UE-specific TA report in RRC\_CONNECTED for Rel-17. 2. If enabled by the network, the UE reports information about UE-specific TA pre-compensation at the random-access procedure (MSGA/MSG3 or MSG5) using a MAC CE. 3. If the UE location is reported to NW with a guaranteed accuracy of an area of a 2km radius, NW could estimate UE-eNB RTT within a 5% error of an NR slot length for all supported SCS. 4. If the UE location is reported to NW with a guaranteed accuracy of an area of a 2km radius, the maximum update frequency shall be every 6s for aircraft and 1 minute for C-IoT devices. 5. If enabled by the network, the UE reports information about UE location during initial access, e.g., via MSG3 or MSG5 using a MAC CE command or RRC parameters. 6. If enabled by the network, the UE reports information about UE location in RRC\_CONNECTED using a MAC CE or an RRC message. The maximum update frequency is 1 minute for C-IoT devices. |
| CMCC | ***Proposal 1:*** For UL scheduling for FDD-HD to avoid UL-DL collisions, cell/beam/UE-specific Koffset and UE-specific TA based solutions need further study, taking latency, signaling overhead, power consumption, and network efficiency into account.  ***Proposal 2:*** UE-specific TA reporting is supported with at least one of following information:   * Option 5: Difference between the last applied K\_offset (e.g., cell-specific K\_offset or UE-specific K\_offset indicated by the network) and one new K\_offset suggested by UE. * Option 4: Difference between UE-specific K\_offset and cell-specific K\_offset. * Option 3: UE location.   ***Proposal 3:*** The decision on UE-specific TA reporting achieved in NR NTN may be reused in IoT NTN with minimum changes, if any, when it is agreed. |
| Intel | Proposal 2:   * Reporting of UE-specific TA calculated based on GNSS information and satellite ephemeris is necessary to enable half-duplex FDD operation   + Subframe-level granularity can be considered for reporting   Proposal 3:   * Consider the following alternatives to decrease UE-specific TA reporting overhead   + Alt 1. Reporting of information to extrapolate/interpolate UE-specific TA (e.g. series of values, 1st order derivative, etc.)   + Alt 2. Reporting of UE location (based on GNSS) |
| Ericsson | **Proposal 4 Evaluate the impact of frequent UE TA reporting on IoT UE power consumption.**  **Proposal 5 If UE specific TA reporting were to be supported for IoT NTN, the reporting mechanism can follow the decision in NR\_NTN\_Solutions WI and reuse the agreements therein for IoT NTN with minimum changes if any.** |
| Apple | ***Proposal 6:*** *For UE-specific TA reporting for HD FDD UEs, support event triggered TA reporting, where the reported TA value has coarse granularity.* |
| ZTE | ***Proposal-6:*** *Full TA reporting is preferred for the purpose of updating K\_offset and avoiding UL-DL collision.*  ***Proposal-7:*** *In case of segment pre-compensation, the value of reported TA can be either the first or last TA values applied at corresponding segment.* |
| Xiaomi | ***Proposal 3: The UE TA reporting can be done with a triggered manner.*** |
| InterDigital | ***Proposal-7:*** *Investigate the benefits of UE-specific Koffset considering additional UE power consumption to report UE-specific TA value regularly.* |
| Lenovo, Motorola Mobility | ***Proposal 2: UE report the TA value in msg3 and report the TA value in the following NPUSCH, the TA can be propagation delay***/***UE-specific TA (reflecting all or partial of round-trip delay) (e.g., one way delay, excluding the feeder link delay).***  ***Proposal 3: Differential TA value can be reported in msg3 or NPUSCH and the differential TA can be the relative value to 1) broadcast common TA; 2) configured cell specific Koffset; 3) (previous) reported TA.*** |
|  |  |

### FIRST ROUND Discussion on UE specific TA

Of the 14 companies that made proposals on UE specific TA, only one think that UE-specific TA reporting is not needed in IoT NTN.

If the UE and eNB are aware of UE-specific TA, the UE-specific Koffset can be derived from UE-specific TA.

The need for UE-specific TA and its reporting mechanisms are under discussion in NR NTN. In FL proposal, IoT NTN can wait to study decisions from NR NTN and then determine whether further enhancements or adaptations are needed.

FL Proposal 7.1.2-1

Wait for decisions with respect to the need for and reporting mechanisms of UE-specific TA and use as starting point.

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| --- | --- | --- |
| Company | Support/Not Support | Comments |
| Intel | Not support | The FL proposal is not clear, seems NR NTN is missing somewhere in the text.  In our view NR NTN and IoT NTN shall be treated separately w.r.t. reporting of UE-specific TA since for IoT NTN the half duplex assumption is much more common comparing to NR and also power consumption is more severe issue for IoT comparing to NR. |
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### Ordering of timing advance and *Koffset* extension operations

### Companies’ Observations and Proposals

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| --- | --- |
| Sony | **Proposal 1: The scrambling code and the DMRS that will be applied to an IoT-NTN UL channel are those that are applicable to the eNB’s UL subframe ( *n* + *nTN* + *Koffset*).** |
| Nokia, Nokia Shanghai Bell | **Proposal 3: It is preferred to avoid additional modification on specification and UE implementation. Thus it is preferred to keep the definition of RS generation in 36.211, i.e. taking the TA into account.**  **This is mainly about which slot index is used for DM RS generation.As in 36.211, the scrambling ID for DM RS is decided by the UL slot index, which take the TA into account, as “where is the first slot of the transmission of the codeword”.**  **If take TA into account, then eNB need to know the exact TA used by UE, which should be common understanding/calculation by UE and eNB, i.e. TA reporting or location reporting.**  **If not take TA into account, then it depends on Dl subframe index + K\_offset to determine scrambling ID.**  **As TA is anyway needed by Node B, it is better to take TA into account as the current definition in 36.211, as no modification to specification and UE implementation in LTE.** |
| Samsung | In Ran1#105-e it was debated whether in the specification of terrestrial NB-IoT and eMTC it is clear that the value *ns* of the subframe that is used in the initialization of the scrambling sequence generator is the subframe number after applying the TA. For NTN, the TA value can be several seconds (multiple subframes), and whether the TA is applied or not to determine the subframe value *ns* used in the initialization is expected to affect the scrambling sequence generation. From TS36.211 Clause 5.3.1 *ns* is the starting frame of the PUSCH transmission, hence the TA has already been taken into account in determining *ns.* It seems there is no need for a clarification in the specifications.  ***Observation 1:*** *From TS36.211 Clause 5.3.1 ns is the starting frame of the PUSCH transmission, hence the TA has already been taken into account in determining ns.* |
|  |  |

## Determining UE-eNB RTT

The intention to estimate UE-eNB RTT is to support the following enhancement in TR 36.763, Clause 8.2, for example, RAR response window offset, mac-ContentionResolutionTimer, UL/DL HARQ RTT timers, and sr-ProhibitTimer.

For NR over NTN, an estimate of UE-gNB RTT is equal to the sum of UE’s TA and K\_mac, where K\_mac is scheduling offset to delay MAC CE action time when DL and UL frame timing are not aligned at gNB. See below.

However, as shown in TR 36.763, apart from Timing advance command activation, the study did not identify any other IoT-NTN configurations needing activation/de-activation via MAC CE and their timing relationships. Thus, there might be no need to reuse K\_mac, but options for determining the estimate of UE-eNB RTT shall be discussed.

### Companies’ Observations and Proposals

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| --- | --- |
| FGI, Asia Pacific Telecom, III, ITRI | 1. Options of determining the estimate of UE-eNB RTT shall be discussed in RAN1, regarding no K\_mac can be reused in IoT over NTN. 2. Introduce a new K\_mac value for the estimate of UE-gNB RTT, where the new K\_mac is assumed to have the unit of millisecond rather than the unit of a PUCH slot. |
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# Other issues and relationships

## Half duplex operation

### Companies’ Observations and Proposals

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| Nokia, Nokia Shanghai Bell | **Observation 2: Operating according to maximum propagation delay in half duplex deployment is resource inefficient.**  **Observation 3: scheduler may avoid UL-DL collision in HD-FDD for UE specific transmission by considering UE specific TA and K\_offset, while it does not work well for cell specific transmission.**  **Observation 4: Reporting each UE specific Timing Advance change leads to high uplink signalling load.**  **Observation 5: Limiting Timing Advance reporting to events where the TA has changed reduces the signalling, but due to moving satellites the signalling is not completely minimized.**  **Observation 6: TA reporting may cause additional large UL resource utilization with UL repetitions.**  **Observation 7: Defining a TA reference, based on UE location, can minimize signalling overhead, because network and UE can both predict TA. UE only needs to report if it has moved.**  **Proposal 2: Reporting UE location for determining UE-specific Timing Advance in half duplex deployments is one method, which can be used by eNB scheduler to avoid UL-DL collisions.** |
| Ericsson | Proposal 3: On UL scheduling for FDD-HD, it is sufficient to use UE-specific TA to avoid UL-DL collisions in FDD-HD |
| Apple | ***Proposal 5:*** *Support HD FDD UEs to report information about UE-specific TA for scheduling to avoid uplink-downlink collision.* |
| ZTE | ***Proposal-4:*** *The UE-specific TA reporting and configuration of UE-specific K\_offset to avoid UL-DL collision in FDD-HD UE should be supported in IoT-NTN.*  ***Proposal-5:*** *For two HARQ-Processes, introduce K\_offset to avoid collision between the UL transmission and potential 2nd PDCCH reception.* |

## UL transmission gap in IoT NTN

### Companies’ Observations and Proposals

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| vivo | ***Proposal 3: Not support to enhance the timing relationship of UL transmission gap in IoT NTN.*** |
| Spreadtrum | ***Proposal 5: Enhancement on the UL transmission gap in IoT NTN is needed.***  Considering the large TA of NTN, the configured transmission gap and the actual transmission gap will not be aligned, as shown in the figure 1. Therefore, the length of transmission gap in existing specifications need to be extended to ensure that the UE has enough time for frequency synchronization.    **Figure 1: Illustration of the misalignment of the configured transmission gap and the actual transmission gap.** |

## PDCCH monitoring restrictions

### Companies’ Observations and Proposals

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| --- | --- |
| vivo | ***Proposal 4:*** ***Support to introduce K\_TA for current restrictions on NPDCCH monitoring for UL transmissions,*** ***where the unit of K\_TA is subframe and the value of K\_TA is derived from TA/UE-specific TA.*** |
| Spreadtrum | ***Proposal 4: PDCCH monitoring restrictions need to be enhanced.*** |
| OPPO | **Proposal 5: RAN1 should study the potential impact on the NPDCCH monitoring due to long RTT.**  **Prospoal 6: RAN1 should study the potential enhancement for NPDCCH monitoring to avoid DL and UL conflicting.** |

## Timing offset for the start of RAR window

### Companies’ Observations and Proposals

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| CATT | **Proposal 8: Estimate the UE-gNB RTT with the equation UE\_RTT = UE-satellite RTT(service link RTT)+feeder link RTT, where feeder link RTT= common delay+K\_mac+delat\_T\*feeder link drift.** |
| OPPO | **Proposal 4: RAR window start is shifted by a timing advance applied for the NPRACH transmission and a K\_mac.** |
| FGI, Asia Pacific Telecom, III, ITRI | 1. For the start of the RAR window, use K\_RTT to start the RAR window at the subframe containing the end of the last preamble repetition plus K\_RTT and the legacy X subframes, where K\_RTT is UE-eNB RTT. |

## Interrupted downlink/Guard subframes

### Companies’ Observations and Proposals

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| Qualcomm | ***Proposal 3*: The definition of downlink interrupted subframes (e.g., those before and after a PUSCH, PRACH, PUCCH, and half-duplex guard periods), where a half-duplex UE is not expected to monitor PDCCH, is modified, in accordance with the large UE-specific TAs in NTN.**  Due to large, UE-specific TAs, DL subframes interrupted due to an UL transmission are UE-specific. Current specs assume a small TA (e.g., up to 1 ms), and do not incorporate a “TA term” in defining these subframes. However, as illustrated in Fig. 1, for NTN, the interrupted subframes need to be defined using a term that captures the impact of this very large TA. In the figure, we want X\_DL to Y\_DL to be the interrupted DL SFs—i.e., the subframes where the UE is not required to monitor another PDCCH, since it must get ready to transmit the PUSCH starting at Y\_UL. Without the “-TA” term for Y\_DL, the interrupted SFs would be from X\_DL +TA to Y\_DL +TA, while it would (problematically) be expected to monitor PDCCH from X\_DL to Y\_DL!  A screen shot of a smart phone  Description automatically generated  Figure 1: Definition of DL interrupted subframes in the presence of large NTN-specific TAs.  Examples (for NB-IoT) where this needs to be reflected include DL subframes before and after a NPUSCH or NPRACH transmission, DL subframes corresponding to half-duplex guard periods, etc. |
| **Nordic Semiconductor ASA** | **Proposal-1**: For eMTC, guard subframes for HD-FDD UE are modified to at least two subframes starting from n + + 4 – , where n is subframe of the UL grant and is timing advance rounded up to number of subframes*.*    Figure 1 Guard interval for eMTC where UE does not expect to receive DL |

### FL Analysis and Proposals on Timing relationships and TA

Whilst the specifications do not explicitly answer the question, we can surmise the answer from the reason the timing relationship is described in the specifications in the first place. The stipulation that the UE ‘is expected to start the PUSCH transmission’ from the start of subframe n+k0’ is a declaration that the eNB is expecting the start of the PUSCH to occur in the UL subframe that coincides with DL subframe n+k0’ at the eNB. The eNB needs this knowledge of the starting subframe because when a PUSCH is transmitted, the initialisation of the generator for the sequence used to scramble the TB carried in the PUSCH is as follows (section 5.3.1 of TS36.211):

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In this equation is the subframe number - in this case, the subframe number of the starting subframe of the PUSCH. It is reasonable to surmise that if *Tt* already takes the TA into account, then the gap at the eNB between transmitting a PDSCH and receiving the PUSCH carrying its HARQ-ACK/NACK would then depend on the UE-specific TA. In NTN where the TA can be 100s of subframes long, the time interval between the eNB transmitting the PDSCH and when it can expect to decode the related HARQ-ACK/NACK would vary from UE to UE by many subframes. Furthermore, the eNB PUSCH decoding procedures will also have to be different for NTN since the scrambling for each PUSCH would also depend on the UE-specific TA at the time of transmission.

Taking this into account, FL suggests the following conclusion based on a study of Rel16 and follows up with a suggested agreement for this SI. FL encourages companies to comment on the proposed conclusion and proposed agreement in the Tables provided.

FL Proposal 1.2-1:

**Conclusion: The description of timing relationships for eMTC and NB-IoT in Rel16 do not take the TA into account.**

**FL Proposal 1.2-2:**

**Proposed agreement: In IoT NTN timing relationships enhanced by extension (e.g. by K-offset) and in which the UE is expected to transmit on the UL (PUCCH, PUSCH, or a signal) in response to a reception on the DL (PDCCH or PDSCH), the UE will apply the timing relationship enhancement by extension prior to applying the TA to the UL transmission.**

# Referenced Documents

[R1-2106486](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106486.zip) Discussion on timing relationship enhancement for IoT in NTN Huawei, HiSilicon

[R1-2106634](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106634.zip) Discussion on timing relationship enhancements for NB-IoT/eMTC over NTN vivo

[R1-2106720](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106720.zip) Discussion on timing relationship enhancements for IOT NTN Spreadtrum Communications

[R1-2106761](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106761.zip) Timing relationship enhancements Qualcomm Incorporated

[R1-2106824](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106824.zip) Timing relationship enhancements for IoT-NTN Sony

[R1-2106921](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106921.zip) Timing relationship enhancements Samsung

[R1-2106954](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106954.zip) Timing relationship enhancement for IoT over NTN CATT

[R1-2107048](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107048.zip) On timing relationship enhancements Nordic Semiconductor ASA

[R1-2107068](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107068.zip) Timing relationship enhancements for IoT NTN MediaTek Inc.

[R1-2107174](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107174.zip) Timing relationship enhancements for NB-IoT/eMTC over NTN Nokia, Nokia Shanghai Bell

[R1-2107248](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107248.zip) Discussion on timing relationship enhancements OPPO

[R1-2107292](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107292.zip) Timing relationship enhancements to NB-IoT NTN FGI, Asia Pacific Telecom, III, ITRI

[R1-2107431](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107431.zip) Discussion on timing relationship enhancements for IoT NTN CMCC

[R1-2107620](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107620.zip) On timing relationship for NB-IoT and eMTC NTN Intel Corporation

[R1-2107660](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107660.zip) On timing relationship enhancements for IoT NTN Ericsson

[R1-2107773](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107773.zip) On Timing Relationship Enhancements in IoT NTN Apple

[R1-2107780](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107780.zip) Discussion on timing relationship for IoT-NTN ZTE

[R1-2107910](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107910.zip) Discussion on the timing relationship enhancement for IoT NTN Xiaomi

[R1-2107943](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107943.zip) Timing Relationship for IoT NTN Lenovo, Motorola Mobility

[R1-2108039](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2108039.zip) On Timing relationship enhancement for IoT NTN InterDigital, Inc.