**3GPP TSG RAN WG1#104e R1-21xxxxx**

**E-meeting, 25 January – 5 February 2021**

Agenda Item: **8.15.3**

Source: **Moderator (Sony)**

Title: **FL summary of AI 8.15.3 Timing relationship for IoT-NTN**

Document for: **Discussion**

# Introduction

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

This Study will evaluate and confirm solutions to address the minimum necessary specifications for NB-IoT and eMTC according to the following objectives.

The second objective is, for the above identified scenarios, to study and recommend necessary changes to support NB-IoT and eMTC over satellite, reusing as much as possible the conclusions of the studies performed for NR NTN in TR38.821. This objective will address the following items:

- Aspects related to random access procedure/signals [RAN1, RAN2]

- Mechanisms for time/frequency adjustment including Timing Advance, and UL frequency compensation indication [RAN1, RAN2]

- Timing offset related to scheduling and HARQ-ACK feedback [RAN1, RAN2]

- Aspects related to HARQ operation [RAN2, RAN1]

- General aspects related to timers (e.g. SR, DRX, etc.) [RAN2]

- RAN2 aspects related to idle mode and connected mode mobility [RAN2]

- RLF-based for NB-IoT

- Handover-based for eMTC

- System information enhancements [RAN2]

- Tracking area enhancements [RAN2]

NOTE 3: GNSS capability in the UE is taken as a working assumption in this study for both NB-IoT and eMTC devices. With this assumption, UE can estimate and pre-compensate timing and frequency offset with sufficient accuracy for UL transmission. Simultaneous GNSS and NTN NB-IoT/eMTC operation is not assumed.

# Overview of Main Issues from company contributions

The following table lists the issues covered by companies’ contributions to this AI at RAN1#104-e. FL has added a comment to indicate FL proposal of how to treat each issue at this meeting.

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| --- | --- | --- |
| **Issue #** | **Issue** | **Proposed Treatment** |
| 1 | Timing relationships requiring enhancement | 1st round email discussion |
| 2 | Koffset Configuration | 1st round email discussion |
| 3 | MAC-CE Activation timing | 1st round email discussion |
| 4 | HD-FDD operation | 1st round email discussion |
| 5 | PDCCH monitoring timing after PRACH | 1st round email discussion |
| 6 | Scheduling delay | Dealt with in issues 1 & 2 |
| 7 | Timing advance | AI 8.15.2 |
| 8 | MAC contention resolution timer | RAN2 Issue? |
| 9 | NPDCCH / MPDCCH monitoring restrictions | Later discussions |
| 10 | UE time / frequency tuning time | Later discussions /RAN4? |
| 11 | UE GNSS measurement | Later discussions |
| 12 | Power saving | Later discussions |
| 13 | PUR and EDT | Later discussions |
| 14 | (N)PRACH before SIB1 | Later discussions |
| 15 | Terrestrial eMTC / NB-IoT timing relationships | Noted |

In the above table, main issues not to be treated in first round appear in red. Companies are urged to concentrate only on the issues to be treated in the first round of email discussions.

## Timing relationships requiring enhancement

Various companies listed the timing relationships that require enhancement (enhancement relative to legacy terrestrial NB-IoT / eMTC operation). The identified timing relationships are taken from the baseline that has been agreed in the NR NTN work.

RAN1 needs to agree which timing relationships need to be altered for IoT-NTN. The following list is suggested by companies:

For NB-IoT, the following timing relationship enhancements are required:

* NPDCCH to NPUSCH format 1 extended by Koffset.
* RAR grant to NPUSCH format 1 extended by Koffset.
* NPDSCH to HARQ-ACK on NPUSCH format 2 extended by Koffset.
* NPDCCH order to NPRACH extended by Koffset.

For eMTC, the following timing relationship enhancements are required:

* MPDCCH to PUSCH extended by Koffset.
* RAR grant to PUSCH extended by Koffset.
* PDCCH order to PRACH extended by Koffset.
* MPDCCH to scheduled uplink SPS extended by Koffset.
* PUSCH to HARQ-ACK on PUCCH extended by Koffset.
* CSI reference resource timing altered by Koffset.
* MPDCCH to aperiodic SRS extended by Koffset.

**2.1.1 Company views**

For NB-IoT, the following timing relationship enhancements are required:

* NPDCCH to NPUSCH format 1 extended by Koffset. CATT, vivo , MTK-Eutelsat, Intel, Len-MM, Spreadtrum, SONY, Xioami, Samsung, Apple
* RAR grant to NPUSCH format 1 extended by Koffset. CATT, vivo, MTK-Eutelsat, Len-MM, Spreadtrum, SONY, APT, Xiaomi, Samsung, Apple
* NPDSCH to HARQ-ACK on NPUSCH format 2 extended by Koffset. CATT , vivo, MTK-Eutelsat, Intel, Len-MM, Spreadtrum, SONY, Xiaomi, Samsung, Apple
* NPDCCH order to NPRACH extended by Koffset. APT, Samsung

For eMTC, the following timing relationship enhancements are required:

* MPDCCH to PUSCH extended by Koffset. CATT, Intel, Len-MM, SONY, Xiaomi, Samsung, Apple
* RAR grant to PUSCH extended by Koffset. CATT, Len-MM, SONY, Xiaomi, Samsung, Apple
* PDCCH order to PRACH extended by Koffset. CATT, Samsung
* MPDCCH to scheduled uplink SPS extended by Koffset. CATT
* PDSCH to HARQ-ACK on PUCCH extended by Koffset. CATT, Intel, SONY, Xiaomi, Samsung, Apple
* CSI reference resource timing altered by Koffset. CATT, Intel, Len-MM, Xiaomi, Apple
* MPDCCH to aperiodic SRS extended by Koffset. CATT, Intel, Len-MM, Xiaomi, Apple

**2.1.2 Related proposals**

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| **Contribution** | **Proposals** |
| CATT | Proposal 1: is required to introduce to enhance following transmission timing for NB-IoT:   * The transmission timing of DCI scheduled NPUSCH format 1. * The transmission timing of RAR grant scheduled NPUSCH format 1. * The transmission timing of HARQ-ACK on NPUSCH format 2.   Proposal 2: is required to introduce to enhance following transmission timing for eMTC:   * The transmission timing of DCI scheduled PUSCH (including CSI on PUSCH). * The transmission timing of RAR grant scheduled PUSCH. * The transmission timing of "PDCCH order" scheduled PRACH. * The transmission timing of MPDCCH scheduled uplink SPS. * The transmission timing of HARQ-ACK on PUCCH. * The CSI reference resource timing. * The transmission timing of aperiodic SRS. |
| Vivo | Proposal 3: Reuse the K\_offset introduced in NR NTN to enhance the following timing relationships in IoT NTN.   * The transmission timing of DCI scheduled NPUSCH. * The transmission timing of RAR grant scheduled NPUSCH. * The transmission timing of HARQ-ACK on NPUSCH. |
| MediaTek Inc. | Proposal 1: Introduce K\_offset to enhance the following timing relationships for NB-IoT NTN is beneficial:   * For NB-IoT, on receiving UL grant on DCI format N0 in slot n, NPUSCH Format 1 is transmitted in subframe n+k0+K\_offset. * 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+k0+K\_offset. * 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+K\_offset. |
| Intel | Proposal 1:   * For eMTC additional slot offset K\_offset is needed at least for PUSCH, HARQ-ACK feedback on PUCCH, aperiodic SRS and CSI reference resource definition * For NB-IoT additional common slot offset K\_offset is needed at least for NPUSCH format 1 and HARQ-ACK feedback on NPUSCH format 2 |
| Lenovo, Motorola Mobility | Proposal 1: At least the following timing relationship should be updated by additional timing offset for IoT NTN   * Transmission timing for (N)PUSCH scheduled by DCI (including CSI on PUSCH (eMTC)) * Transmission timing for (N)PUSCH scheduled by RAR grant * Transmission timing for HARQ-ACK on PUCCH (eMTC) or NPUSCH format 2 (NBIoT) * CSI reference resource timing (eMTC) * Aperiodic SRS transmission timing (eMTC) |
| Sony | Proposal 3: The legacy Rel-16 timing relationship is applied between MPDCCH and PDSCH.  Proposal 4: The MPDCCH to PUSCH timing relationship is extended by *Koffset* subframes.  Proposal 5: The RAR to PUSCH timing relationship is extended by *Koffset* subframes.  Proposal 6: The PDSCH to PUCCH timing relationship is extended by *Koffset* subframes. |
| Asia Pacific Telecom, FGI | Proposal 3: Additional scheduling offset for Msg3 shall be considered regarding a need of NW to ensure UE to complete the Msg3 transmission with a required TA value.  Proposal 5: The UE processing time for an NPDCCH ordered NPRACH may need a revisit considering a potential need of using a TA value on the NPRACH transmission.  Proposal 7: For NPUSCH scheduling, a new offset value might be needed if the current spec context describes the procedure by assuming TA = 0.  Proposal 8: For HARQ-ACK feedback, a new scheduling offset value on top of k0 shall be considered if the current specs describe the procedure assuming TA = 0. |
| Xiaomi | Proposal 1: The timing relationship agreed in NTN WI can be reused as the baseline design. |
| Samsung | Proposal 1: For NTN-IoT, a timing offset Koffset is required for   * the transmission timing of DCI scheduled PUSCH (including CSI on PUSCH) * the transmission timing of RAR grant scheduled PUSCH * the transmission timing of HARQ-ACK on PUCCH * the transmission timing of PRACH triggered by a PDCCH order |
| Apple | Proposal 3: A cell specific is used to enhance the timing relationship of RAR grant scheduled PUSCH and HARQ-ACK to Msg 4.  Proposal 5: The is used to enhance the timing relationship of DCI scheduled PUSCH, DCI scheduled aperiodic SRS, HARQ-ACK on PUCCH, and CSI reference resource timing. |

**2.1.3 Timing relationships requiring enhancement Issues for email discussion**

It seems from 2.1.1 and 2.1.2 that there is broad consensus as to which timing relationships should be enhanced and in most cases, how they should be enhanced to follow at least the solutions agreed in NR NTN. Based on this assertion, the FL proposals are as follows.

FL Proposal 1.1:

For NB-IoT, at least the following timing relationships shall be enhanced with an additional timing offset as required:

* NPDCCH to NPUSCH format 1
* RAR grant to NPUSCH format 1
* NPDSCH to HARQ-ACK on NPUSCH format 2
* NPDCCH order to NPRACH

Companies are invited to indicate (Yes/No) on FL Proposal 1.1 and comment as necessary.

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| Company | FL Proposal 1.1 | Comment |
| Ericsson | Too early | There are various timing relationships specified for eMTC and NB-IoT, e.g., timing offset related to scheduling and HARQ-ACK feedback. However, it is not often clear whether it takes into account timing advance (TA). It is our view that RAN1 should first discuss existing eMTC and NB-IoT timing relationships to reach a common understanding, before discussing any potential required adjustment(s) within the context of NTN.  In fact, understanding of existing timing relationships was heavily discussed in Rel-15 NR maintenance. Common understanding based on the conclusion at RAN1#98bis can be found in R1-1911583. This eventually formed the basis for NR NTN work. Similar exercise is needed for IoT NTN.  In short, it is necessary to first align common understanding of existing specification text instead of jumping into conclusion directly. |
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FL Proposal 1.2:

For eMTC, at least the following timing relationships shall be enhanced with an additional timing offset as required:

* MPDCCH to PUSCH
* RAR grant to PUSCH
* PDCCH order to PRACH
* MPDCCH to scheduled uplink SPS
* PUSCH to HARQ-ACK on PUCCH
* CSI reference resource timing
* MPDCCH to aperiodic SRS

Companies are invited to indicate (Yes/No) on FL Proposal 1.2 and comment as necessary.

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| Company | FL Proposal 1.2 | Comment |
| Ericsson | Too early | There are various timing relationships specified for eMTC and NB-IoT, e.g., timing offset related to scheduling and HARQ-ACK feedback. However, it is not often clear whether it takes into account timing advance (TA). It is our view that RAN1 should first discuss existing eMTC and NB-IoT timing relationships to reach a common understanding, before discussing any potential required adjustment(s) within the context of NTN.  In fact, understanding of existing timing relationships was heavily discussed in Rel-15 NR maintenance. Common understanding based on the conclusion at RAN1#98bis can be found in R1-1911583. This eventually formed the basis for NR NTN work. Similar exercise is needed for IoT NTN.  In short, it is necessary to first align common understanding of existing specification text instead of jumping into conclusion directly. |
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FL Proposal 1.3: Use NR NTN solutions (addition of Koffset) as baseline.

Companies are invited to indicate (Yes/No) on FL Proposal 1.3 and comment as necessary.

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| Company | FL Proposal 1.3 | Comment |
| Ericsson | Too early | There are various timing relationships specified for eMTC and NB-IoT, e.g., timing offset related to scheduling and HARQ-ACK feedback. However, it is not often clear whether it takes into account timing advance (TA). It is our view that RAN1 should first discuss existing eMTC and NB-IoT timing relationships to reach a common understanding, before discussing any potential required adjustment(s) within the context of NTN.  In fact, understanding of existing timing relationships was heavily discussed in Rel-15 NR maintenance. Common understanding based on the conclusion at RAN1#98bis can be found in R1-1911583. This eventually formed the basis for NR NTN work. Similar exercise is needed for IoT NTN.  In short, it is necessary to first align common understanding of existing specification text instead of jumping into conclusion directly. |
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## Koffset Configuration

The Koffset value that is introduced in NR NTN can be used for various aspects of IoT-NTN functionality.

There are expected to be fewer satellite beams for IoT-NTN than for NR NTN. Should there be beam-specific Koffset values signaled in SIB? A counter-argument is that IoT traffic is not delay sensitive and hence there is no point trying to optimize the Koffset value and a cell-specific value may be acceptable.

It was agreed in NR NTN that a single Koffset value for initial access will be signaled in the SI per cell. Companies have raised similar issues here.

How many values of Koffset should there be?

* Cell specific Koffset for initial access
* UE-specific Koffset during connected mode
* Beam specific Koffset values

How are Koffset values determined by the UE?

* Cell specific signaling (e.g. SIB)
  + Per cell
  + Per beam
* UE-specific signaling
* Implicitly determined

The Koffset value, at least for initial access, should be capable of supporting the RTT to the furthest UE in the NTN cell/beam coverage. It seems like this does not need to be specified and that a reasonable eNodeB implementation may choose the Koffset value appropriately.

### Issue Discussion

2.2.1.1 Cell specific vrs beam specific Koffset for initial access

RAN1#103-e agreement for NR NTN

Agreement:

* For K\_offset configured in system information and used in initial access, at least a cell specific K\_offset configuration, which is used in all beams of a cell, should be supported.
* FFS: Beam specific K\_offset configured in system information and used in initial access.

The FSS part for NR NTN is also under discussion at this meeting.

**Company views**

Cell specific Koffset should be supported in initial access. Spreadtrum, Samsung, Apple, Len-MM, Samsung, NOK-NSB

Beam-specific Koffset values supported. MTK-Eutelsat, Spreadtrum

There is no beam processing in LTE. NOK-NSB

FL Question 2.1: Should the Koffset for initial access be cell-specific or beam-specific?

2.2.1.2 Koffset for initial access should be explicitly signaled in SI

RAN1#103e agreement in NR NTN implies explicit configuration in SI.

Agreement:

* For K\_offset **configured in system information** and used in initial access, at least a cell specific K\_offset configuration, which is used in all beams of a cell, should be supported.

**Company views**

Koffset should be carried in system information. Zhejiang, IDC

Koffset should be derived implicitly based on other parameters, such as common TA. Zhejiang, SONY

FL Question 2.2: Should Koffset for initial access be explicitly configured in SI or implicitly signaled?

2.2.1.3 UE-specific Koffset during connected mode

**Company views**

UE-specific Koffset value can avoid collisions in HD-FDD and avoid unused DL subframes. MTK-Eutelsat

UE-specific timing offsets can be applied after initial access in order to account for the large variation in TA between UEs in a cell. Samsung

For NB-IoT, the latency is not critical and the latency saving from UE-specific offset does not justify the signaling overhead to a potentially large number of UEs Apple

Koffset value applied depends on the configured Koffset and the TA difference between first TX and last TX of a set of repetitions. NOK-NSB

FL Question 2.3: Should IoT-NTN support a UE-specific Koffset in connected mode?

### Related proposals

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| **Tdoc#** | **Proposals** |
| Huawei, HiSilicon | Proposal 1: Reuse the Koffset introduced in NR NTN to enhance the timing relationships in IoT NTN. |
| Zhejiang Lab | Proposal 1: K\_offset can be introduced and carried in system information to support NB-IoT/eMTC and in which procedure (s) should K\_offset be introduced can be further discussed.  Proposal 2: Implicit signaling of K\_offset value(s) should be supported. |
| MediaTek Inc. | Observation 1: Configuration of a beam-specific K\_offset requires beam-specific K\_offset to be broadcast on SIB increases system information overhead in a satellite cell with moderate number of beams and may be acceptable trade-off between UL scheduler flexibility in initial access and SIB overhead.  Proposal 2: The value of K\_offset can be re-configured after RRC connection setup based on UE-specific autonomous TA report. |
| Spreadtrum Communications | Proposal 1: The K\_offset introduced in NR NTN can be reused in IoT NTN.  Proposal 2: Cell specific K\_offset configuration should be supported and used in initial access.  Proposal 3: Updating of the Koffset from cell-specific to beam-specific after initial access for IOT NTN should be supported. |
| Sony | Proposal 1: The timing relationship between certain physical channels is extended by *Koffset* subframes in order to enable operation in IoT-NTN cells with large propagation delays.  Proposal 2: RAN1 selects between the following options for determining *Koffset*:   * *Koffset* is explicitly signaled to the UE * UE implicitly determines *Koffset* value based on other cell parameters, such as a common timing offset if broadcasted by the eNB |
| Nokia, Nokia Shanghai Bell | Proposal 1: configured K\_offset and timing distance difference between the first transmission and the repetiton could be used to generate the new K\_offset for the repetition.  Observation 1: Large complexity for IoT UE and large standard effort are needed for IoT UE in NTN to support beam specific processing.  Proposal 2: beam specific processing is not introduced into LTE IoT NTN and Cell-specific K\_offset could be used for time relation in IoT NTN.  Observation 2: there are ways to cover multiple beams, to guarantee both beamforming gain and timing relationship.  Proposal 3: multiple deployments for timing relationship with satellite beams should be studied and compared, considering complexity and standard effort. |
| Samsung | Proposal 2: Cell specific timing offset is transmitted in SIB with a single value for adjusting the transmission timings of DCI scheduled PUSCH, RAR grant scheduled PUSCH and HARQ-ACK on PUCCH.  Proposal 3: Discuss whether to allow reconfiguration to a UE-specific timing offset after initial access.  Proposal 4: Discuss the existing timing relationships of NB-IoT and eMTC for NTN. |
| Apple | Proposal 1: IoT over NTN reuses the principle of the timing relationship enhancement in NR over NTN.  Proposal 2: A cell specific is configured as system information and is used in initial access.  Proposal 4: A cell specific is used after initial access at least for NB-IoT devices.  Proposal 6: RAN1 to study how to align the scheduling timing between UE and network. |
| InterDigital, Inc. | Proposal 1: A Koffset value carried in system information is used to adapt timing relationship enhancements in NB-IoT/eMTC to an NTN environment. |

### Koffset Configuration Issues for email discussion

On the 3 different issues related to the number, configuration and UE-specific Koffset, some companies have expressed views that lie on both sides of each issue. As only a few companies have expressed a view on each of these issues, in the email discussion, we would like to get the views of more companies.

FL Question 2.1: Should the Koffset for initial access be cell-specific or beam-specific?

Companies are kindly asked to indicate the view (Cell-specific/Beam-specific) in the relevant column and provide a comment.

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| Company | Cell or beam-specific Koffset? | Comment |
| Ericsson | Cell specific | Follow progress in NR NTN WI |
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FL Question 2.2: Should Koffset(s) for initial access be explicitly configured in SI or implicitly signaled?

Companies are kindly asked to indicate their view (Explicit /Implicit) in the relevant column and provide a comment if necessary.

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| Company | Explicit or Implicit Configuration | Comment |
| Ericsson | Too early | Too early to decide, especially this is a SI. Follow progress in NR NTN WI |
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FL Question 2.3: Should IoT-NTN support a UE-specific Koffset in connected mode?

Companies are kindly asked to indicate the view (Yes/No) in the relevant column and provide a comment if necessary.

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| Company | UE-specific Koffset in connected mode? | Comment |
| Ericsson | No | IoT NTN is delay tolerant. |
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## MAC-CE activation timing.

The NR NTN work item has agreed that an offset, K\_mac, to the MAC CE in PDSCH is needed for the case that:

* DL and UL frame timing are not aligned at the eNB
* For UE action on a downlink configuration indicated in MAC CE command.

The same principle can be applied in IoT-NTN.

In NR-NTN WI, the MAC-CE activation time was discussed extensively and in RAN1#103e meeting, there was a consensus that according to whether the gNB has aligned DL and UL timing, the DL MAC-CE activation time may or may not need an additional offset.

The RAN1#103-e agreement on NR NTN regarding this issue is as follows:

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| Agreement:  Denote by K\_mac a scheduling offset other than K\_offset:   * If downlink and uplink frame timing are aligned at gNB:   + For UE action and assumption on downlink configuration indicated by a MAC-CE command in PDSCH, K\_mac is not needed.   + For UE action and assumption on uplink configuration indicated by a MAC-CE command in PDSCH, K\_mac is not needed. * If downlink and uplink frame timing are not aligned at gNB:   + For UE action and assumption on downlink configuration indicated by a MAC-CE command in PDSCH, K\_mac **is needed**.   + For UE action and assumption on uplink configuration indicated by a MAC-CE command in PDSCH, K\_mac is not needed. * Note: This does not preclude identifying exceptional MAC CE timing relationship(s) that may or may not require K\_mac. |

### Company views

NR NTN MAC CE activation time principle to be applied in IoT-NTN. OPPO.

### Related proposals

Proposal 5: For NB-IoT-NTN, adopt the same MAC-CE activation time principle as NR-NTN. OPPO.

### MAC-CE Activation Timing Issues for email discussion

Only one company expresses a view on this issue. It is not clear what configurations are activated/deactivated via MAC CE. In the email discussion we wish to collate the views of more companies.

**FL Question 3.1:** Which IoT-NTN configurations need to be activated / deactivated via MAC-CE?

Companies are kindly asked to list examples of IoT/MTC MAC-CE activated / deactivated configurations.

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| Company | MAC-CE affected configurations | Comment |
| Ericsson |  | MAC CE timing relationship is complicated. It requires case by case analysis. |
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**FL Proposal 3.2:** For IoT-NTN, adopt the NR-NTN MAC-CE activation time solution as baseline.

If there are MAC-CE activated / deactivated configurations, companies are kindly asked to indicate their view (Yes/No) in the relevant column and provide a comment if necessary.

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| Company | Adopt FL Proposal 3.2? | Comment |
| Ericsson | Too early | MAC CE timing relationship is complicated. It requires case by case analysis. Further, there may be differences between IoT NTN and NR NTN. So, study is needed first. |
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## HD-FDD operation

IoT/MTC devices can support both HD-FDD and FD-FDD operation, as well as TDD operation.

IoT-NTN cell sizes can be large which can lead to a large differential delay (up to 10.3ms from TR38.821). These large differential delay values may lead to collisions of simultaneous UL and DL transmissions for a half-duplex UE needing solutions to avoid or mitigate such collisions. Before RAN1 engages in the search for such solutions, it is probably useful to first decide on the kinds of duplex that an IoT-NTN device is expected to support.

### Company views

Support HD-FDD operation. OPPO, Xiaomi, IDC

The large TA and large differential TA in a cell may introduce collisions of simultaneous UL transmission and DL reception for a half-duplex UE. HW/HiSi, Xiaomi, IDC.

Consider ways to either (1) avoid or (2) handle UL/DL conflicts in HD-FDD operation. IDC

Subframes where UE is not expected to monitor NPDCCH due to potential DL/UL collision need to take account of the extended timing advance in IoT-NTN. Qualcomm

UE may monitor for NPDCCH during “waiting periods” (e.g. between NPDSCH and transmitting HARQ ACK/NACK), especially when Koffset is cell-specific and cells are large. Qualcomm.

### Related proposals

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| **Source** | **Proposals** |
| Oppo | Proposal 2: UE is expected to operate in half-duplex mode for FDD. |
| HW/HiSi. | Proposal 2: Study solutions for the possible collision between UL transmission and DL reception for half- duplex UE caused by large TA and large differential TA. |
| Xiaomi | Proposal 2: The impact on the timing relationship caused by half duplex operation need to be studied. |
| IinterDigital Communications | Proposal 2: Study solutions to address the potential conflict between DL and UL for HD-FDD UEs when Koffset is used. |
| Qualcomm | Observation 1: For half-duplex UEs (including NB-IoT and HD eMTC UEs), the interrupted downlink subframes due to an uplink transmission are UE-specific and related to the UE-specific TA.  Proposal 2: RAN1 to study 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, in the light of large TAs in NTN.  Proposal 3: RAN1 to study enabling PDCCH monitoring in “waiting periods”—for example, between receiving NPDSCH and transmitting HARQ ACK in NB-IoT—to mitigate suboptimal throughput. |

### HD-FDD Operation Issues for Email Discussion

The issue of DL/UL conflict or overlap in HD-FDD has been raised by companies saying this will require a study and solutions. Such solutions could look at whether the eNB-based scheduler can resolve such collisions for HD-FDD UEs and what additional information would the eNB need to be able to avoid DL / UL collisions?

**FL Questions 4.1:** Should solutions to support HD-FDD operation be studied?

Companies are kindly asked to give their view (Yes/No) on whether such overlap in DL/UL requires study and in the comments, indicate what aspects need studying.

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| Company | Study Required | Comments on what aspects to study |
| Ericsson | Need study first | Concrete problem statements should be formulated to align understanding before delving into solutions. |
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## PDCCH monitoring timing after PRACH

Due to the large propagation delay in NTN, UE may not receive the RAR grant in response window if the propagation delay is much larger than the length of response window. Therefore, a timing offset may need to be applied to the start of ra-ResponseWindow in IoT NTN relative to the end of the PRACH transmission.

Companies further express the view that after PRACH transmission, the RAR window start is shifted to cover the UE-specific RTT and the UE can go into sleep mode to save power.

How is the RAR window location defined, taking into account the R16 offset between PRACH and RAR window and any Koffset-type delay introduced for IoT-NTN? Is this a RAN2 issue?

**The issue of ra-ResponseWindow offset in NR NTN was discussed in RAN2#112-e and is pending resolution.**

### Company views

After PRACH transmission, the UE can go to sleep mode to save power and the RAR window start is shifted to cover the UE-specific RTT. OPPO.

How does the existing offset between PRACH and RAR window relate to the new IoT-NTN delayed RAR window location? APT

### Related proposals

Proposal 1: introduce a K offset to delay the RAR window start. OPPO

Observation 5: A timing offset need be applied to the start of ra-ResponseWindow in IoT NTN. Vivo

Proposal 2: If an offset used to adjust the start of ra-ResponseWindow will be introduced, how to cope with the existing offset X in the legacy NB-IoT shall be considered. APT

### PDCCH monitoring timing after PRACH Issues for Email Discussion

There are effectively two issues here.

**FL Proposal 5.1:** NR NTN solution to RAR window timing is baseline for IoT-NTN.

Companies are kindly asked to indicate their view (Yes/No) on FL Proposal 5.1 and comment as necessary.

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| Company | Support FL Proposal 5.1? | Comments |
| Ericsson | Yes | Follow progress in NR NTN WI |
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**FL Proposal 5.2:** Should IoT-NTN UE go to sleep mode to save power whilst waiting for the RAR window start?

Companies are kindly asked to indicate their view (Yes/No) on FL Proposal 5.2 and comment as necessary.

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| --- | --- | --- |
| Company | Power saving? | Comments |
| Ericsson | Need discussion | Which mode UE can go to should be discussed, possibly with coordination with RAN2. |
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## Scheduling delay

The scheduling delay needs to provide sufficient time for NPDCCH / MPDCCH decoding as well as to account for the large RTT-related timing advance.

The scheduling delay needs to account for the UE-specific TA, especially the different delay aspect.

### Company views

Scheduling delay: to take into account the half duplex constraint and long timing advance. OPPO, Qualcomm

### Related proposals

Proposal 3: The scheduling delay for NPUSCH needs to cover a UE-specific TA. OPPO.

Proposal 1: RAN1 to study mechanisms for UE reporting of UE-specific TA for half-duplex UEs over NTN, including mechanisms for updating the TA when it changes. Qualcomm

### Scheduling delay Issues for Email Discussion

The FL considers that this issue will be covered by issues 2.1 and 2.2.

**FL Conclusion:** This issue will be resolved through Issues 2.1 and 2.2.

Companies are invited to agree/disagree and comment as necessary.

|  |  |  |
| --- | --- | --- |
| Company | Agree? | Comments |
| Ericsson | Yes | This can be treated as part of 2.1 and 2.2. |
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## Timing advance.

Clarification of legacy functionality

Several companies suggested that there should be clarification / a common understanding on the operation of Rel-16 NB-IoT / eMTC timing advance. This clarification could possibly be made with reference to the figure below.



Full TA vs partial TA

Full TA: the timing advance is fully compensated such that the UL and DL frame timings are aligned.

Partial TA: A common timing offset in the eNB’s frame timing exists. The UE then compensates for the differential delay only.

UE-specific timing advance indication

The eNB needs to know the UE-specific timing advance so that it can properly account for this in its scheduling delay. This avoids collisions between UL and DL in HD-FDD UEs and avoids wasted subframes (unused subframes if the eNB always assumes maximum differential TA). This signaling is in contrast to terrestrial NB-IoT / eMTC, where the timing advance is controlled by the eNB.

UL timing advance overlap

If UL timing advance is changed by more than a single subframe, then how is UL transmission overlap handled?

### Company views

eNB needs to know UE-specific TA for properly handing the scheduling delay. OPPO, MTK-Eutelsat, Intel, Qualcomm

Discuss whether full TA or partial TA is used. vivo.

Need a common understanding of how terrestrial timing advance operates for eMTC, NB-IoT. Ericsson, APT.

Timing advance maintenance needs to consider impact of UL transmission overlap that extends beyond a single subframe. APT

Timing advance value may change during a along set of repetitions. NOK-NSB

### Related proposals

Proposal 4: the gNB needs to know the UE-specific TA for properly handling the scheduling delay. OPPO.

Proposal 1: Whether full TA or partial TA is used in IoT NTN should be discussed. vivo.

Observation 2: 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. MTK-Eutelsat

Observation 3: For half-duplex UEs (including NB-IoT and HD eMTC), configuring K\_offset value to maximum differential TA may cause interruption of DL subframes. MTK-Eutelsat

Observation 4: For connected half-duplex UEs (including NB-IoT and HD eMTC), updating the K\_offset value based on UE autonomous TA report can avoid collision issue between DL and UL subframes and interrupted DL subframe issue. MTK-Eutelsat

Observation 5: It is sufficient if the UE autonomously acquired TA report is sent by UE about every 20 seconds (=500 µs / 25.33 µs) to avoid DL-UL subframe collision issue in LEO. MTK-Eutelsat

Proposal 2: The value of K\_offset can be re-configured after RRC connection setup based on UE-specific autonomous TA report. MTK-Eutelsat

Proposal 3: The UE can report at least report its autonomous TA to the gNB in Message 3 during initial cell access. MTK-Eutelsat

Proposal 4: RAN1 to study UE reporting of UE-specific TA for half-duplex UE in NTN where MTK-Eutelsat

* gNB triggers an autonomous TA report from the UE
* UE initiates report autonomous TA report

Proposal 2: Reporting of additional TA applied by the UE to compensate service link delay calculated based on GNSS information and satellite ephemeris should be supported. Intel

Observation 1: It is not clear whether the various timing relationships in eMTC and NB-IoT take into account timing advance (TA). Ericsson.

Proposal 1: RAN1 to first discuss existing eMTC and NB-IoT timing relationships to reach a common understanding, before discussing any potential required adjustment(s) within the context of NTN. Ericsson.

Proposal 6: Enhancement on TA maintenance shall consider any impact on UL transmission overlap. APT

[area of proposal 7] Does the spec describe “actual timing” of “logical timing” for TA? APT

[section 2.2] Timing advance may change during a long set of repetitions for LEO. NOK-NSB

Proposal 1: RAN1 to study mechanisms for UE reporting of UE-specific TA for half-duplex UEs over NTN, including mechanisms for updating the TA when it changes. Qualcomm

### Timing Advance Issues discussion

**FL Conclusion 7.1:** This issue is best handled in AI 8.15.2?

Companies are kindly requested to express their view (Yes/No on FL conclusion 7.1 and comment as necessary.

|  |  |  |
| --- | --- | --- |
| Company | Agree? | Comments |
| Ericsson | No | Common understanding is needed before e.g. discussing applicability of Koffset to IoT NTN. |
|  |  |  |
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## MAC contention resolution timer

General comments

Contention resolution timers are a RAN2 issue.

### Company views

Unit in which contention resolution timer needs to be counted needs to be decided. APT.

### Related proposals

Proposal 4: If an offset used to adjust the start of mac-ContentionResolutionTimer will be introduced, whether to reuse an NPDCCH period as a unit shall be FFS. APT

### MAC contention resolution timer Issues for Discussion

**FL Conclusion 14.1:** MAC contention resolution timer is discussed in RAN2.

Companies are kindly requested to indicate whether or not they agree with this FL conclusion and comment as necessary.

|  |  |  |
| --- | --- | --- |
| Company | Agree? | Comment |
| Ericsson | Agree | Up to RAN2 |
|  |  |  |

## NPDCCH / MPDCCH monitoring restrictions

General comments

Having time periods in which the UE is not required to monitor NPDCCH / MPDCCH would have the following benefits:

* Avoid UL / DL collisions in HD-FDD.
* Power saving.
* Allows time for UE to decode NPDCCH / MPDCCH (this is a reason in the legacy terrestrial NB-IoT functionality).

### Company views

In terrestrial NB-IoT, there is a time between NPDCCH reception and NPUSCH transmission where the UE does not need to monitor for NPDCCH. This helps to avoid UL / DL collision. [FL: it also helps the UE to be able to complete NPDCCH processing before transmitting NPUSCH when there are limited CPU resources in the UE]. Consider changing the time in which the UE is not required to monitor for NPDCCH. ZTE.

### Related proposals

Proposal 2: Limitation on NPDCCH monitoring in the spec should be modified accordingly if the K\_offset is introduced in the time relationship. ZTE

### NPDCCH / MPDCCH monitoring restrictions Issues for discussion

**FL issues**

What are the reasons for applying NPDCCH / MPDCCH monitoring restrictions:

* Avoid UL / DL collisions in HD-FDD.
* Power saving.
* Allows time for UE to decode NPDCCH / MPDCCH (this is a reason in the legacy terrestrial NB-IoT functionality).
* Other (please specify)

## UE time / frequency tuning time

General comments

There is an UL compensation gap inserted in NB\_IoT and eMTC UL transmissions to allow an HD-FDD UE to correct its time-frequency synchronization. It should be studied whether changes to the UL compensation gap are required to account for the large RTT in IoT-NTN

A guard period can be applied around the start / end of an UL transmission to allow RF re-tuning / symbol alignment. This is necessary when the eNB does not know the UE-specific TA.

### Company views

Resolve collision issues in the presence of UL compensation gap in PUSCH. CATT.

Resolve collision issues in the presence of UL compensation gap in PRACH. CATT.

Allow guard periods around UL transmissions to allow for frequency / time adjustment by UE. MTK-Eutelsat.

### Related proposals

Proposal 3: Study the solutions to resolve the collision issues in the presence of transmission gap for IoT NTN in HD-FDD. CATT

Proposal 4: Add a guard period before the start of transmission gap to solve transmission collision for uplink transmission of IoT NTN in HD-FDD. CATT

Proposal 5: Guard Period Around the start / end of UL transmission is configured. MTK-Eutelsat.

### UE time / frequency tuning time Issues for discussions

**FL considerations**

Do UL compensation gaps for PUSCH and PRACH need to be extended to account for RTT?

Do we need to allow guard periods around UL transmissions to allow the UE to update time / frequency synchronization?

## GNSS measurement

General comments

If the UE does not have a valid GNSS measurement, timing relationships may need to be extended to allow the UE to transmit in the uplink following downlink reception.

### Company views

UE can extend timing between PDSCH and PUCCH in order to make a GNSS measurement if it doesn’t previously have a valid TA. SONY.

### Related proposals

Proposal 7: When the UE is scheduled PDSCH and does not have a valid GNSS measurement, the timing relationship between PDSCH and PUCCH is extended by a time that is sufficient to perform a GNSS measurement. SONY

### GNSS measurement Issues for discussions

**FL considerations**

The UE needs to have accurate timing and frequency compensation before UL transmission. How do the IoT-NTN timing relationships allow the UE to perform measurements for such compensation (e.g. through GNSS measurement)?

## Power saving

General comments

There are various proposals covering different issues that impact power saving:

* From the timing point of view, can the UE sleep at certain times to save power, e.g. partial coverage NTN
* Sleep between PRACH and start of RAR window
* UE only needs to make a GNSS measurement if it does not have valid TA and needs to transmit in the UL

### Company views

Consider power saving from timing point of view: NOK-NSB

UE can extend timing between PDSCH and PUCCH in order to make a GNSS measurement if it doesn’t previously have a valid TA in order to save power. SONY

### Related proposals

Proposal 4: it could be studied from timing PoV on power saving in NTN scenario, with e.g. partial coverage of NTN network. NOK-NSB

Proposal 7: When the UE is scheduled PDSCH and does not have a valid GNSS measurement, the timing relationship between PDSCH and PUCCH is extended by a time that is sufficient to perform a GNSS measurement. SONY

After PRACH transmission, the UE can go to sleep mode to save power and the RAR window start is shifted to cover the UE-specific RTT. OPPO.

### Power saving Issues for Discussions

**FL considerations**

Is there an impact of timing relationships on power consumption?

## PUR and EDT

General comments

PUR requires the UE to have valid TA before transmission. In NTN, the TA may change rapidly. Do there need to be updated procedures for PUR?

Do procedures for EDT need updating, given that in EDT, TA is validated in the Msg1 / Msg2 exchange.

In general, what set of R16 eMTC and NB-IoT features need to be supported in IoT-NTN?

### Company views

Discuss timing offsets for PUR and EDT in NTN-IoT. Samsung

### Related proposals

Proposal 5: Discuss timing offsets for transmission of preconfigured uplink resources and EDT in NTN-IoT. Samsung

### PUR and EDT Issues for discussions

**FL considerations**

Which set of R16 features need to be supported by IoT-NTN?

Is the study going to only consider baseline functionality?

Should there be some prioritization of what is supported?

Should the study seek to support PUR and EDT features in Rel17 IoT-NTN?

## (N)PRACH before SIB1

General comments

SIB1-NB can update the PRACH configuration. A large timing advance might mean the (N)PRACH is transmitted with an out of date (N)PRACH configuration.

### Company views

NPRACH may be transmitted with an out of date configuration with respect to SIB1-NB. APT.

### Related proposals

Proposal 1: Whether consider the initial TA to determine a valid NPRACH occasion shall be FFS. APT

### (N)PRACH before SIB1 Issues for Discussions

**FL Considerations**

Does RAN1 need to consider changes in PRACH configuration signaled in system information? If PRACH configuration is not changed frequently, the network might be able to tolerate some inadvertent PRACH transmission due to an out of date configuration in system information.

## Terrestrial eMTC / NB-IoT timing relationships

General comments

Legacy timing relationships for NB-IoT and eMTC are provided by ZTE, CATT

The tables below are taken from the ZTE Tdoc:

Table Timing relationships in NB-IoT

|  |  |  |  |
| --- | --- | --- | --- |
| Row  index | Timing relationship description | Value of time offset (FDD)  (ms) | Value of time offset (TDD)  (ms or subframe) |
| 1 | Timing offset for reporting ACK/NACK on NPUSCH | 12,20 if SCS is 3.75kHz, 12,14,16,17 if SCS is 15kHz | The value is k on the top of 12 subframe, and  k is 0,8 UL subframe for SCS=3.75kHz,  k is 0,2,4,5 UL subframe for SCS=15kHz |
| 2 | Timing offset for DCI scheduled NPUSCH | 8,16,32,64 | The value is k on the top of 8 subframe, and  k is 0,8,16,32 UL subframe |
| 3 | Timing offset for RAR grant scheduled NPUSCH  (Also can be configured with additional Scheduling delay field () in RAR) | 12,16,32,64 | The value is k on the top of 8 subframe, and  k is 4,8,16,32 UL subframe |
| 4 | start of Msg2 RAR window | 4,41 | 4 |
| 5 | PDCCH order PRACH | the value is k ≥ 8 |  |
| 6 | Applying time of timing advance command | 12 |  |
| 7 | start of monitoring PUR response window | 4 |  |

Table Timing relationships in eMTC

|  |  |  |
| --- | --- | --- |
| Row  index | Timing relationship description | Value of time offset (FDD)  (ms) |
| 1 | Timing offset for reporting ACK/NACK on MPUCCH | 4,5,6,7,8,9,10,11,13,15,17 |
| 2 | Timing offset for DCI scheduled PUSCH | 4 |
| 3 | Timing offset for RAR grant scheduled PUSCH  (Also can be configured with UL delay in RAR grant) | For CEmodeA,  PUSCH is transmitted in next available UL subframe after n+k1+Δ, if UL delay field is set to 1,  The value is k1, if UL delay field is set to 0,  DL-SCH transport block reception ending in subframe n, and Δ is the number of Msg3 PUSCH repetitions, e.g. 2. k1≥6. |
| 4 | start of Msg2 RAR window | 3 |
| 5 | PDCCH order PRACH | the value is k2 ≥ 6 |
| 6 | Applying time of timing advance command | 6 |
| 7 | start of monitoring PUR response window | 4 |

# Contact Details

Please fill in the optional table below with contact details.

|  |  |  |
| --- | --- | --- |
| Company | Delegate | Email address |
| SONY | Sam Atungsiri | Sam.atungsiri@sony.com |
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# References

The following documents were submitted to RAN1#104e before the Tdoc deadline:

|  |  |  |
| --- | --- | --- |
| [R1-2100162](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100162.zip) | Discussion on timing relationship enhancements | OPPO |
| [R1-2100235](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100235.zip) | Discussion on timing relationship enhancement for IoT in NTN | Huawei, HiSilicon |
| [R1-2100250](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100250.zip) | Discussion on timing relationship for IoT-NTN | ZTE |
| [R1-2100367](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100367.zip) | Timing relationship enhancement for NB-IoT/eMTC | CATT |
| [R1-2100482](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100482.zip) | Discussion on timing relationship enhancements on NB-IoT/eMTC for NTN | vivo |
| [R1-2100495](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100495.zip) | Timing relationship enhancements to support NB-IoT/eMTC in Non-Terrestrial Network | Zhejiang Lab |
| [R1-2100602](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100602.zip) | Timing relationship enhancements | MediaTek Inc. |
| [R1-2100684](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100684.zip) | On timing relationship for NB-IoT and eMTC NTN | Intel Corporation |
| [R1-2100764](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100764.zip) | Timing relationship enhancements for IoT NTN | Lenovo, Motorola Mobility |
| [R1-2100811](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100811.zip) | Consideration on timing relationship enhancements | Spreadtrum Communications |
| [R1-2100876](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100876.zip) | Timing relationship for IoT-NTN | Sony |
| [R1-2100932](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100932.zip) | On timing relationship enhancements for IoT NTN | Ericsson |
| [R1-2100977](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2100977.zip) | Timing relationship enhancements to NB-IoT in NTN | Asia Pacific Telecom, FGI |
| [R1-2101029](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101029.zip) | Timing relationship enhancements for NB-IoT/eMTC over NTN | Nokia, Nokia Shanghai Bell |
| [R1-2101106](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101106.zip) | Discussion on the timing relationship enhancement for IoT NTN | Xiaomi |
| [R1-2101244](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101244.zip) | On timing relationship enhancements | Samsung |
| [R1-2101370](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101370.zip) | Discussion on Timing Relationship Enhancement in IoT NTN | Apple |
| [R1-2101403](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101403.zip) | On timing relationship enhancement for IoT NTN | InterDigital, Inc. |
| [R1-2101514](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Docs/R1-2101514.zip) | Timing relationship enhancements | Qualcomm Incorporated |

1. RP-193235. “Study on NB-IoT / eMTC support for Non-Terrestrial Network”. RANP#86. Sitges, Spain. December 2019.
2. 3GPP TR 38.821, Solutions for NR to support non-terrestrial networks (NTN), V16.0.0.