**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.

|  |  |  |
| --- | --- | --- |
| **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**

|  |  |
| --- | --- |
| **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.

|  |  |  |
| --- | --- | --- |
| 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. |
| ZTE | Discussion is needed per case | For the NB-IoT and eMTC, more complicated timing indication is designed including additional parameters and assumption. As identified in our contribution (R1-2100250), in some cases, e.g., RAR scheduled PUSCH, additional enhancements may not be needed. Then, considering the new scenario of IoT-NTN, the timing relationships mentioned in the contributions should be identified one by one with common understanding on the existing specification. |
| Huawei | Need further study | Agree with Ericsson that it is too early to make a decision. In principle, similar timing relationship enhancement to that of NR NTN can be considered but we need to check carefully whether enhancement is needed. |
| CMCC | Need further study | Same comment as above. |
| Xiaomi | Need further study | We share Ericsson’s view |
| Spreadtrum | Need further discussion | In principle, similar timing relationship enhancement in NR NTN can be considered. |
| Samsung | Further study | A timing offset should be taken into account in the timing relationships of these channels. The specific impact to the various timing equations can be different for the different channels and needs to be studied. |
| CATT | Need further study | We share same view with Ericsson. |
| vivo | Further study | These timing relationships have to be studied firstly. |
| MediaTek | Further study | The K\_offset solution used in NR NTN for the timing relationships can be used on a per case basis for NB-IoT / eMTC NTN timing relationships.  We would prefer the proposal to align with RAN1#98bis conclusions as proposed in our TDoc on a case by case   * 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.   It would be helpful to discuss the impact of long RTT on each timing relationship in NB-IoT / eMTC. Identify if there are specific issues for NB-IoT / eMTC NTN compare to NR NTN that would require further discussion.  We are fine with Ericsson suggestion to further discuss the TA understanding with long RTT. The TA is used in cellular NB-IoT or eMTC for UL synchronization. To our understanding, longer RTT in LEO / GEO would still require use of TA similarly to NR NTN for UL synchronization. The Koffset is a solution used for the timing relationships. This is needed even with assumption that UE is perfectly synchronized on UL as was discussed in NR NTN.  In eNB, there is no overlapping of UL and DL subframes in FDD assuming UE are synchronized on UL. It is up to the eNB to schedule UL transmissions taken into account the long RTT. The Koffset is needed to avoid scenario where for example UE receives UL grant on DCI in slot n, but would need to advance the transmission by several hundreds of ms due to long RTT before transmitting NPUSCH Format 1 in UL subframes n+k0. This would not be possible without the Koffset for the same reasons as in NR NTN for corresponding case. We see no difference for this case. |
| SONY | Can discuss on case by case basis | We think that all of the items in the FL proposal need a timing offset added. We think that a single offset can be applied to each of the timing relationships, i.e. there is a single K\_offset value that the UE would apply.  Our understanding of the existing timing relationships is that they are defined for the case where there is zero timing advance. Any timing advance applied thus “eats into” the UE processing timeline between channels. We are OK to first clarify existing timing relationships before moving on to IoT-NTN timing relationships.  We are OK to discuss each timing relationship on a case by case basis, but assume that the outcome is that the enhancement will be the same for each relationship. |
| Nokia, NSB | Further study | Same view as Ericsson. It is too early to say enhancement is needed or not before any discussion on that. Further study is needed for each case. |
| APT | Yes, with changes | Replace shall be enhanced to shall be FFS. We may go deeper on these procedures first. |

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. |
| ZTE | Discussion is needed per case | Similar as the comment for Proposal 1.1. |
| Huawei | Need further study | Same comment as for the FL proposal 1.1. |
| CMCC | Need further study | Same comment as above. |
| Xiaomi | Need further study | Same comment as the previous proposal |
| Spreadtrum | Need further discussion | In principle, similar timing relationship enhancement in NR NTN can be considered. |
| Samsung |  | Same comment as in Proposal 1.1. |
| vivo | Further study | Same comment as in Proposal 1.1. |
| MediaTek | Further discuss | Same comment as in Proposal 1.1 |
| SONY | Can discuss on case by case basis | Similar to the comment for proposal 1.1. i.e.:   * Can consider on case by case basis * OK to initially confirm common understanding of legacy terrestrial operation   A specific concern is the CSI resource reference timing. CSI measurements are likely to be out of date after a long RTT and so may not be useful. However, it might be necessary to define the timing relationship even if CSI is of limited use. |
| Nokia, NSB | Further study | Same view as Ericsson. It is too early to say enhancement is needed or not before any discussion on that. Further study is needed for each case. |
| APT | Yes, with changes | Replace shall be enhanced to shall be FFS. We may go deeper on these procedures first. |

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.

|  |  |  |
| --- | --- | --- |
| 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. |
| ZTE |  | W.r.t the solution, if the necessity for corresponding case is identified for timing enhancement, introduction of K\_offset can be the baseline solution for discussion, e.g., to address the impact of larger RTT. Other solution to address different issue will be discussed case by case. |
| Huawei | Need further study | The principle of NR NTN can be considered, but we need to discuss the existing timing relationship first and figure out whether NR NTN solutions could work out as the baseline. |
| CMCC |  | Same view as ZTE. |
| Xiaomi | Support if introduction of K\_offset is needed |  |
| Spreadtrum | Yes |  |
| Samsung |  | We think that the various timing relationships have to be studied first. No need to agree to this proposal. |
| vivo | Yes |  |
| MediaTek |  | Same comment as in Proposal 1.1 |
| SONY |  | Preference is to align with the NR NTN solution (addition of Koffset to timing relationships).  If the conclusion of FL proposals 1.1 and 1.2 is that each timing relationship is going to be considered individually, then at this stage it seems premature to agree that the NR NTN solution will be applied for each timing relationship. |
| Nokia, NSB | Further study | Possible but further study needed before any agreement. |
| APT | Yes | This might be a working assumption for companies. |

## 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

|  |  |
| --- | --- |
| **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.

|  |  |  |
| --- | --- | --- |
| Company | Cell or beam-specific Koffset? | Comment |
| Ericsson | Cell specific | Follow progress in NR NTN WI |
| ZTE | Beam-specific is prioritized | For the IoT case, impact of different satellite parameter along with beam layout should be considered. |
| Zhejiang Lab | both | Cell-specific as baseline and beam-specific can be further supported to optimize the latency when needed. |
| Huawei | Cell specific | According to NR NTN, at least cell-specific Koffset should be supported. |
| CMCC | Cell specific | IoT NTN is delay tolerant. |
| Apple | Cell specific | Like NR NTN, at least cell specific Koffset is supported. |
| Xiaomi | At least cell specific | At least cell-specific Koffset can be supported following NTN outcome. FFS the support of beam specific Koffset |
| Spreadtrum | Cell specific | Considering that NB-IOT is not very sensitive to delay, cell specific Koffset is enough to meet the requirements in initial access. |
| Samsung | Cell specific | As in NR NTN |
| CATT | Cell specific | For IoT NTN, the delay is not critical. |
| vivo | Cell-specific | Same as NR-NTN, at least cell specific Koffset is supported. |
| MediaTek | Cell specific | As in NR NTN, beam specific Koffset could be FFS |
| SONY | Depends on definition of beam and cell | The choice depends to an extent on what a “beam” is. An IoT-NTN beam seems to have different characteristics to an NR NTN beam. Our preference is for cell-specific |
| Nokia, NSB | Cell specific | Cell specific K\_offset will have much less UE complexity and standard effort and LTE does not support beam related processing. |
| APT | Cell specific | At least |

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.

|  |  |  |
| --- | --- | --- |
| Company | Explicit or Implicit Configuration | Comment |
| Ericsson | Too early | Too early to decide, especially this is a SI. Follow progress in NR NTN WI |
| ZTE |  | Be open to study, basically the structure of issues on the indication can follow NR-NTN, e.g. include initial value, and update. |
| Zhejiang Lav | Implicit | Reduce signaling overhead |
| Huawei | Implicit | Same view as NR NTN, implicit indication can save the signaling overhead |
| CMCC | Need further study | Follow NR-NTN. |
| Apple | Explicit | We could wait for the detailed design of Koffset before making a decision. |
| Xiaomi | Too early | Share Ericsson’s view |
| Spreadtrum | Need further study |  |
| Samsung |  | This can be discussed in the WI phase. |
| vivo | Further study | Follow NR-NTN. |
| MediaTek |  | This issue is under discussion in NR NTN, we can wait for progress in NR NTN. |
| SONY | Follow NR NTN | Both explicit and implicit can be considered at this stage. We can follow progress in NR NTN.  If Koffset can be calculated from other parameters in SIB, then Koffset can be calculated implicitly and there is no need for separate Koffset signaling. |
| Nokia, NSB | Further study | Too early to decide. Further study needed for IoT NTN cases. |
| APT | Explicit | Signaling reduction is not the primary objective for this SI |

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.

|  |  |  |
| --- | --- | --- |
| Company | UE-specific Koffset in connected mode? | Comment |
| Ericsson | No | IoT NTN is delay tolerant. |
| ZTE | Up to the whole structure of design | If the beam specific offset can be introduced starting from initial access, no much need to optimized the K\_offset for scheduling.  But if only the cell specific offset K\_offset is supported, optimization to introduce a parameter is needed. Otherwise, the overall UE will suffered from the latency for scheduling and even in some case, the beam switching will occur during the reception of scheduling and corresponding data transmission due to large K\_offset for LEO. |
| Huawei | No | It is not evident that for IoT NTN UE-specific offset is of benefit in connected mode. The UE would have to report its TA for UE-specific Koffset which will increase the power consumption of UE |
| CMCC | Need further study | It may be relative to HD-FDD operation. |
| Apple | No | In IoT over NTN, the motivation of using a UE specific time offset is not strong. The latency is not the critical KPI for IoT devices. For example, the latency requirement is up to 15 ms for eMTC devices and up to 10 seconds for NB-IoT devices. The maximum differential delay in an NTN cell is acceptable in network scheduling, comparing with the latency requirements of NB IoT devices. On the other hand, using a cell specific for all UEs in an NTN cell after initial access could save the signaling related to calculating UE specific . This signaling saving is significant in case the number of IoT devices in an NTN cell is large. |
| Xiaomi | Too early | At least UE-specific update of the Koffset should be avoided. |
| Spreadtrum | No | NB-IOT is not very sensitive to delay. Furthermore, supporting UE-specific Koffset will increase the power consumption of UE. |
| Samsung |  | We think this can be studied. A UE specific Koffset can be helpful in large cells. |
| vivo | No | The UE-specific K\_offset needs to be updated frequently due to the fast movement of satellite. It’s very unfriendly to the repetition transmission in the IoT. |
| Mediatek | Yes | The motivation is HD FDD operations in NB-IoT / eMTC NTN. There are two issues with using the K\_offset value configured to a smaller value than the maximum differential TA in case of FDD-Half-Duplex Systems:  - Collision of DL and UL subframes, where DL and UL scheduling by the BS collide at the UE  - Interrupted DL subframes when the eNB schedules an UL subframe to one or several UEs, but cannot schedule DL transmissions for the other UEs within the maximum differential TA. |
| SONY | Can be studied | The main use case for a UE-specific Koffset would be to potentially handle HD-FDD collisions.  Given that the RTT is already large, applying a UE-specific Koffset to minimize the effect of any differential RTT seems to be an unnecessary optimization. |
| Nokia, NSB | Too early | Too early to decide. Further study needed for different cases. |
| APT | No | Assume UE may not stay in RRC\_CONNECTED or in DRX inactive for very long time. |

## 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:

|  |
| --- |
| 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.

|  |  |  |
| --- | --- | --- |
| Company | MAC-CE affected configurations | Comment |
| Ericsson |  | MAC CE timing relationship is complicated. It requires case by case analysis. |
| ZTE |  | Include this case in issue 2.1 with clarification. |
| Huawei |  | This needs more careful analysis before making a conclusion. |
| CMCC |  | Same comment as above. |
| Apple |  | More studies are needed. |
| Spreadtrum |  | Need further study |
| Samsung |  | It needs to be studied. |
| CATT |  | Need more study. |
| vivo |  | Need further study, and it can be merged into issue 2.1. |
| MediaTek |  | It can be further studied |
| SONY |  | Time at which TA command applies.  An initial task would be to determine which configurations are applicable to IoT-NTN. |
| Nokia, NSB |  | Further study needed |
| APT | No | Only 6-bit timing advance command (TAC) MAC CE may need some attention |

**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.

|  |  |  |
| --- | --- | --- |
| 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. |
| ZTE | No | Comment as above for **FL Question 3.1.** |
| Huawei | Needs further study | As NR NTN is still discussing this topic, it is too early to draw conclusions regarding proposal 3.2. We also have not analyzed the differences between NR-NTN and NB-IoT/eMTC with respect to MAC CE timing. |
| CMCC | Needs further study | Same comment as above. |
| Apple | No | Depending on the discussion of FL proposal 3.1. |
| Spreadtrum |  | Need further study |
| Samsung |  | It needs to be studied. |
| CATT |  | Need further study |
| vivo | Too early | Need further study. |
| MediaTek |  | It can be further studied |
| SONY | No | Once RAN1 has agreed on a list of configurations that need activation / deactivation via MAC-CE, RAN1 can consider how the activation time is handled on a case-by-case basis. |
| Nokia, NSB |  | Further study needed |
| APT | No | The above NTN agreement is not for the TAC MAC CE |

## 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

|  |  |
| --- | --- |
| **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.

|  |  |  |
| --- | --- | --- |
| 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. |
| ZTE | Yes | HD-FDD is key feature to reduce the cost of IoT device. And corresponding issue along with solutions should be studied. And timing related issues can be listed in this agenda. E.g. a basic issue for HD-FDD UE mentioned in section 2.9 should be moved to this section. |
| Huawei | Yes | Our understanding is that there will be collision between UL and DL of HD-FDD when large TA is applied, so the study is needed. |
| CMCC | Yes | HD-FDD is the most typical IoT device type. Thus HD-FDD operation should be supported. |
| Xiaomi | Yes | The DL and UL collision as well as possible UL transmissions collision issues need to be studied |
| Spreadtrum | Need further study |  |
| Samsung | Yes | This needs to be studied. It can be done later in the study. |
| CATT | YES | HD-FDD is one important case, so we need to study related timing, especially for the gap configuration in long UL transmission. Current gap is only defined with 40ms, not enough for DL signal reception if long RTT exists. |
| vivo | Yes | HD-FDD is a typical feature of IoT, and the collision between UL and DL may be cause by the fast movement of satellite. |
| MediaTek | Yes | First identify the issues with HD-FDD operations. |
| SONY | Yes | HD-FDD operation is a key aspect of both NB-IoT and eMTC operation. Agree that it would be good to list potential issues arising from HD-FDD operation. These include:   * UL / DL collisions * UE-applied timing advance (the eNB may not have full knowledge of the UL/DL timing offset at the UE)   When does UE need to monitor PDCCH? |
| Nokia, NSB | Yes | It should be studied as HD-FDD is used by most of NB-IoT and eMTC UE. |
| APT | Yes | We do not see any issue but support FFS. |

## 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.

|  |  |  |
| --- | --- | --- |
| Company | Support FL Proposal 5.1? | Comments |
| Ericsson | Yes | Follow progress in NR NTN WI |
| ZTE | Yes | Follow the NR and offset for RAR window monitoring can be considered. |
| Huawei | Yes | Follow the principle adopted in NR NTN. |
| CMCC | Yes | Follow NR NTN. |
| Apple | Yes |  |
| Spreadtrum | Yes | Follow the principle adopted in NR NTN. |
| Samsung |  | We agree to follow NR NTN progress. As discussion is still ongoing in NR NTN, this agreement can be done later. |
| CATT | Yes | Follow NR NTN |
| vivo | Yes | Follow NR NTN. |
| MediaTek | Yes | Follow progress in NR NTN WI |
| SONY | Yes | Given that this issues was discussed in RAN2#112e for NR NTN, this is likely to be discussed in RAN2 for IoT-NTN too. RAN1 could agree that this issue is considered in RAN2. |
| Nokia, NSB | Yes | Follow NR NTN |
| APT | Yes |  |

**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.

|  |  |  |
| --- | --- | --- |
| Company | Power saving? | Comments |
| Ericsson | Need discussion | Which mode UE can go to should be discussed, possibly with coordination with RAN2. |
| ZTE | Need discussion | Open to discuss. Re-organize this issue together with other aspect related to power saving in agenda 8.15.5 is preferred. |
| Huawei | Need further study | What a UE does in the time it waits for RAR is up to the UE. There is no need for RAN1 to agree anything here. |
| CMCC | Need discussion | Same view as ZTE. |
| Apple |  | Open to discussion |
| Spreadtrum | Need further study |  |
| Samsung |  | This can be studied. |
| CATT |  | Need further study |
| vivo |  | Need further study |
| MediaTek | Up to UE implementation | RAN2#111e made agreement “1. From RAN2 perspective, an offset is applied to the start of ra-ResponseWindow in NTN for both LEO and GEO scenarios.”. After transmitting Msg1 in RACH procedure, the UE can go to sleep during the duration of time corresponding to the offset applied to start of ra-ResponseWindow to save power consumption. This is highly preferable in GEO where the RTT can be up to half a second. It is up to the UE implementation. |
| SONY | Yes | We are open for further discussion on this issue.  Power consumption is an important KPI for NB-IoT and eMTC. We share ZTE’s view and would like to see issues related to power consumption in AI 8.15.5 considered as part of the study. |
| Nokia, NSB | Further study | Further study in IoT NTN |
| APT | Not sure | Current behavior is to skip NPDCCH monitoring, but not sure what is “sleep mode” |

## 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. |
| ZTE | Yes | Scheduling delay for NPUSCH can be moved to 2.1.  UE reporting UE-specific TA can be either discussed together with 2.4 or AI 8.1.5.2 for synchronization. |
| Huawei | Yes | Agree with FL conclusion |
| CMCC | Yes | Agree with FL conclusion |
| Apple | Yes | This can be addressed together with issues 2.1 and 2.2. |
| Spreadtrum | Yes |  |
| Samsung |  | We agree with the FL’s conclusion. |
| CATT | Yes | Agree with FL conclusion |
| vivo | Agree | Agree with FL conclusion. |
| MediaTek | Yes | UE-specific TA report can be discussed in question 2.3 in Section 2.2.3 |
| SONY | Yes | Scheduling delay is part of the timing relationships discussion in section 2.1 |
| Nokia, NSB | Yes | To be discussed in 2.1 and 2.2 |
| APT | Yes |  |

## 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. |
| ZTE | Yes | It’s fine to handle it in AI8.15.2 similar as issue above. But clear understanding on the whole timing definition/assumption or IoT should be clarified firstly. |
| Huawei | Yes | We can follow the similar discussion as NR NTN, but some definition can be clarified in this AI |
| CMCC | Yes | Agree with FL conclusion |
| Apple |  | Timing advance itself can be handled in AI 8.15.2. The Koffset related topics (e.g., how to obtain Koffset) can be handled in AI 8.15.3. |
| Spreadtrum | Yes |  |
| Samsung |  | It needs further study. It can handled either here or in 8.15.2. |
| CATT | Yes | Agree with FL conclusion |
| vivo |  | The timing definition should be clarified firstly, common understanding is needed before the timing enhancement. |
| MediaTek |  | Timing advance is used for UL synchronization. The full TA and common timing offset for UL synchronization are discussed in NR NTN. We can wait for progress in NR NTN first.  We repeat below the comment in Proposal 1.1 in Section 2.1 on TA understanding for timing relationships:  We are fine with Ericsson suggestion to further discuss the TA understanding with long RTT. The TA is used in cellular NB-IoT or eMTC for UL synchronization. To our understanding, longer RTT in LEO / GEO would still require use of TA similarly to NR NTN for UL synchronization. The Koffset is a solution used for the timing relationships. This is needed even with assumption that UE is perfectly synchronized on UL as was discussed in NR NTN.  In eNB, there is no overlapping of UL and DL subframes in FDD assuming UE are synchronized on UL. It is up to the eNB to schedule UL transmissions taken into account the long RTT. The Koffset is needed to avoid scenario where for example UE receives UL grant on DCI in slot n, but would need to advance the transmission by several hundreds of ms due to long RTT before transmitting NPUSCH Format 1 in UL subframes n+k0. This would not be possible without the Koffset for the same reasons as in NR NTN for corresponding case. We see no difference for this case. |
| SONY | No | UE specific timing advance indication has implications on HD-FDD operation. If HD-FDD operation is considered in this AI, then so should UE specific timing advance indication issues.  UL timing advance overlap should be handled in this AI. |
| Nokia, NSB | Yes | It could be. But TA and K\_offset should be discussed as a complete solution. |
| APT | No | Better not. Too much impact. |

## 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 |
| ZTE | Agree | Up to RAN2 |
| Huawei | Agree | Up to RAN2 |
| CMCC | Agree | Up to RAN2 |
| Apple | Agree |  |
| Spreadtrum | Agree | Up to RAN2 |
| Samsung | Yes |  |
| CATT | Agree | Up to RAN2 |
| vivo | Yes | Up to RAN2. |
| SONY | Agree | RAN2 |
| Nokia, NSB | Yes | Up to RAN2 |
| APT | Agree |  |

## 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?

|  |  |
| --- | --- |
| Company | Comment |
| ZTE | Open to discuss UL compensation gap, that involves HD-FDD, and also time frequency synchronization in another agenda. |
| Huawei | The UP gap extension may not needed to be extend based on RTT but should take the updating period of system information into consideration. To compensate the timing and frequency drift of long UL transmitting during, guard period is needed. |
| Spreadtrum | We shared the similar views with ZTE. |
| CATT | Current gap is only 40 ms used for DL synchronization tracking, but the long RTT will make timing misalignment between UE and gNB. For UE side, from TX to RX, it need wait for a period to get DL signal to re-turn the time and frequency, where the period may include DL signal transmission, Base station signal switching and UE re-calculating the TA. So one guard period should be reserved. |
| MediaTek | UL compensation gap is discussed in AI 8.15.2. We do not see a need to discuss it in AI 8.15.3 |
| SONY | UL compensation gaps need to be discussed in this study. We are open to consider this issue in AI8.15.2, since requirements on the length of UCG and time between UCG depend on timing accuracy and frequency accuracy, where these accuracies are considered in AI8.15.2 |
| Nokia, NSB | Perhaps revisit this question after working on the koffset and the HD-FDD issues |
| APT | Better to address in AI 8.15.2.  UL compensation gap (UCG) is for long UL transmission and how to maintain UL timing alignment due to long UL transmission is discussed in AI 8.15.2. |

## 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?

|  |  |
| --- | --- |
| Company | Comment |
| ZTE | As baseline, we need to discuss the potential impact for all relevant feature in case of NTN**.** |
| Huawei | It is perhaps too early to consider R16 NB-IoT and Emtc features at this stage. |
| Spreadtrum | It is too early to consider R16 NB-IoT and Emtc features at this stage. |
| CATT | It is too early to consider R16 NB-IoT and Emtc features at this stage. |
| MediaTek | Can be de-prioritized. |
| SONY | While it would be desirable to consider all R16 features in the study, RAN1 needs to prioritise the features studied, given the timeplan for the IoT-NTN study item. |
| APT | Prefer study all Rel-16 features. The same discussion for PUR and EDT is also in RAN2. |

## (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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| Apple | Chunxuan Ye | Chunxuan\_ye@apple.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.