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

Agenda Item: **8.15.2**

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Document for: **Discussion**

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# Introduction

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

[106bis-e-IoT-NTN-02] Email discussion/approval on timing relationship enhancements with checkpoints for agreements on October 14 and 19 – Sam (Sony)

# Overview of Main Issues from company contributions

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

* Timing relationships for NB-IoT / eMTC: as listed in Section 6.6.3 in TR 36.763
* UL scheduling for FDD-HD: Use of UE-specific TA and/or K\_offset to avoid UL-DL collisions in FDD-HD
* Signaling aspects in UE-specific TA maintenance and reporting, techniques to reduce the signaling load and determination of the UE-specific TA.

At RAN1#106e, many of the NB-IoT and eMTC timing relationships were agreed for enhancement. A few timing relationships were discussed but agreement was not reached on the need for enhancement nor how to enhance. Signaling aspects of UE-specific TA were also discussed but agreement was not reached.

Analysis of companies’ contributions to this AI at RAN1#106bis-e shows that a substantial majority concentrated on outstanding timing relationships for both NB-IoT and eMTC and this issue of UE-specific TA. A few other issues were also raised in contributions and these are also summarised in this FL document.

For this first round of email discussions, companies are invited to make their views known in the following sections:

* 3.1
* 3.2
* 3.3
* 3.4
* 4

# Outstanding Timing Relationships for IoT NTN

FL considers company contributions in both NB-IoT and eMTC together on each timing relationship.

## NPDCCH order to NPRACH

In Section 6.6.3 of TR 36.763, this relationship is listed as FFS. At RAN1#106e, this timing relationship was also discussed but without agreement. Companies have continued to study this.

###  Companies’ Observations and Proposals

|  |  |
| --- | --- |
| Sony | **Proposal 1: For NB-IoT, when a UE receives an NPDCCH ending in DL subframe n and carrying a PDCCH order for an NPRACH, the UE should start NPRACH transmission at any UL subframe after DL subframe n+8+ *Koffset* in which an NPRACH resource is available.****Proposal 2: For eMTC and a PDCCH order whose last subframe is received in subframe *n*, the UE will transmit PRACH in the next available subframe after subframe n + 6 + *Koffset* (“k2 ≥ 6”) where PRACH resource is available.** |
| Samsung | **Proposal 1: For NB-IoT in NTN, introduce an additional delay of *k\_offset* subframes before transmission of a random access preamble when the random access procedure is initiated by a PDCCH order.** |
| Nokia, Nokia Shanghai Bell | **Proposal 1**: **K\_offset should be introduced for N/MPDCCH ordered (N)PRACH, where (N)PRACH is transmitted with a delay of Koffset as compared to transmission as per current specification.** |
| CMCC | ***Proposal 1:*** For NB-IoT/eMTC, introducing K\_offset to enhance the timing of PDCCH order to PRACH. |
| ZTE | ***Proposal-2:*** *For NB-IoT/eMTC over NTN, introduce K\_offset to enhance the timing of PDCCH order to PRACH.* |
| Xiaomi | ***Proposal 1: For random access procedure initiated by a NPDCCH order received in downlink slot , UE determines the next available NPRACH occasion after uplink slot to transmit the ordered NPRACH.*** |
| Spreadtrum Communications | ***Proposal 5: For random access procedure initiated by a N/MPDCCH order received in downlink slot n, UE determines the next available PRACH occasion after uplink slot n+K\_offset to transmit the ordered PRACH.*** |
| vivo | ***Proposal 3:*** ***Support to introduce K\_offset to enhance the timing relationship of M/NPDCCH order to PRACH*.*** ***UE-specific K\_offset is used if it’s configured, otherwise, cell-specific K\_offset is used.***
 |
| FGI, Asia Pacific Telecom, III, ITRI | Proposal 3: For an NPDCCH order to NPRACH, introduce K\_offset to start transmission of the random-access preamble at the end of the first DL subframe n + k2 + K\_offset. FFS: Which value of K\_offset should be applied. |
| Apple | ***Proposal 1:*** *In NB-IoT over NTN, enhance the timing relationship of NPDCCH ordered NPRACH transmission based on cell specific* $K\_{offset}$*.****Proposal 2:*** *In eMTC over NTN, enhance the timing relationship of MPDCCH ordered PRACH transmission based on a cell specific* $K\_{offset}$*.* |

### FIRST ROUND Discussion on NPDCCH order to NPRACH

10 companies make proposals on timing relationship enhancement for N/MPDCCH ordered PRACH and all support enhancement of this timing relationship.

Furthermore, at RAN1#106e, this issue was discussed for NR NTN and the following agreement was reached:

Agreement:

For random access procedure initiated by a PDCCH order received in downlink slot $n$, UE determines the next available PRACH occasion after uplink slot $n+K\_{offset}$ to transmit the ordered PRACH.

* Note: The UE’s TA is based on the RAN1#104bis-e agreement on Timing Advance applied by an NR NTN UE given by  $T\_{TA}=\left(N\_{TA}+N\_{TA, UE-specific}+N\_{TA,common}+N\_{TA,offset}\right)×T\_{c}$, where $N\_{TA}=0$ is assumed for PDCCH ordered PRACH.
* FFS: Which value of $K\_{offset}$ should be applied
* FFS: Whether the $n+K\_{offset}$ timing relationship is impacted by UE behavior within or after the validity duration.

In previous RAN1 meetings, this timing relationship has been discussed in detail for both NR-NTN and IoT-NTN. Since enhancement of this timing relationship has been agreed for NR NTN, FL thinks it should also be enhanced for IoT NTN. However, the NR NTN agreement cannot be directly adopted for IoT NTN.

The current specification for NB-IoT (section 16.3.2 of TS36.213) describes this timing relationship as follows:

In case a random access procedure is initiated by a "PDCCH order" ending in subframe *n*, the UE shall, if requested by higher layers, start transmission of random access preamble at the end of the first subframe , , where a NPRACH resource is available.

The current specification for eMTC (section 6.1.1 of TS36.213) describes this timing relationship as follows:

In case a random access procedure is initiated by a "PDCCH order" in subframe *n* for non-BL/CE UEs, or "PDCCH order" reception ending in subframe *n* for BL/CE UEs, the UE shall, if requested by higher layers, transmit random access preamble in the first subframe , , where a PRACH resource is available.

FL makes the following proposal with respect to both NB-IoT and eMTC and invites companies to indicate their support and comment accordingly.

FL Proposal 3.1.2-1:

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

|  |  |  |
| --- | --- | --- |
| Company | Support/Not Support | Comments |
| SONY | Support |  |
| Ericsson | Support |  |
| ZTE | Support |  |
| CATT | Support |  |
| Mavenir | Support |  |
| MediaTek | Support |  |
| Nokia, NSB | Support |  |
| Lenovo, MotoM | Support |  |
| Huawei, HiSilicon | Support |  |
| Xiaomi | Support |  |
| CMCC | Support |  |
| vivo | Support |  |
| GateHouse | Support, with comment | Equals the comment in section 3.2.2-1. |
| Novamint | Support  |  |

## PRACH Preamble Retransmission

According to TS 36.213 section 6.1.1, for eMTC, if the UE fails to receive RAR to a recent PRACH transmission in the subframe *n* where it expected to receive the RAR, the UE shall be, if requested by higher layers, ready to transmit a new preamble sequence no later than in subframe *n*+4 or *n*+5 based on different situations.

According to TS 36.213 section 16.3.2, for NB-IoT, if a UE fails to receive RAR to a recent PRACH transmission in the subframe *n* where it expected to receive the RAR, the UE shall be, if requested by higher layers, ready to transmit a new preamble sequence no later than the NB-IoT UL subframe starting 12 milliseconds after the end of subframe *n*.

As the TA in IoT NTN is likely the duration of multiple subframes, companies have studied this timing relationship.

###  Companies’ Observations and Proposals

|  |  |
| --- | --- |
| Huawei, HiSilicon | ***Observation 1:*** *According to the current specification, a UE can select a proper occasion for PRACH retransmission by taking into account effect of timing advanced applied at the UE.****Proposal 1:*** *For NB-IoT, there is no need to enhance the timing relationship of NPRACH preamble retransmission.* |
| Spreadtrum Communications | ***Proposal 6: If the UE determines that a preamble retransmission is necessary, the choice of a suitable preamble retransmission slot shall be delayed by K\_offset as compared to current specification.*** |
| vivo | ***Proposal 1:*** ***For eMTC in NTN, support to introduce K\_offset to enhance the timing relationship of preamble retransmission*.*****Proposal 2:*** ***For NB-IoT in NTN, not support to enhance the timing relationship of preamble retransmission*.** |
| Sony | **Observation 1:** **For IoT NTN, timing relationship enhancement of preamble retransmission is needed.****Proposal 3: For IoT NTN, if the UE determines that a preamble retransmission is necessary, the choice of a suitable preamble retransmission slot shall be delayed by Koffset as compared to current specification.** |
| Samsung | **Proposal 2: For NB-IoT, on receiving a NPDSCH with no RAR message or not successfully decoded that ends in subframe *n* or not receiving a NPDCCH scheduling a RAR in subframe *n*, where subframe *n* is the last subframe of the RAR window, a new PRACH preamble is transmitted with a delay of *k\_offset* as compared to transmission as per current specification.** |
| CATT | **Proposal 1: For NB-IoT in NTN, timing enhancement of preamble retransmission is needed.****Proposal 2: For eMTC in NTN, timing enhancement of preamble retransmission is needed.** |
| OPPO | **Proposal 5: It should reach an agreement on the understanding of “subframe n” before discussing the preamble retransmission.**  |
| CMCC | ***Observation 1:*** If DL subframe n is used for timing of PRACH preamble retransmission, there is no need for enhancement on timing relationship enhancement.***Proposal 2:*** If DL subframe n is used for timing of PRACH preamble retransmission, FFS whether specification modification for clarification is needed, e.g.,***Proposal 3:*** If UL subframe n is used for timing of PRACH preamble retransmission, support timing enhancement based on K\_offset. |
| Xiaomi | *Proposal 2: For IoT NTN, the preamble retransmission should be performed on a slot that is delayed by an offset as compared to current specification* |
| ZTE | ***Proposal-3:*** *For NB-IoT/eMTC over NTN, introduce K\_offset to enhance the timing of preamble retransmission.* |

### FIRST ROUND Discussion on PRACH Preamble Retransmission

10 companies make observations and proposals on this issue. Of these, 6 companies propose that this timing relationship should be enhanced by adding Koffset.

Huawei, HiSilicon propose that enhancement is not needed in NB-IoT and explains that ‘the timing relationship of NPRACH transmission defined in current specification can be fulfilled by UE implementation by taking the effect of TA into consideration, and there is no need to introduce enhancement for NPRACH retransmission’. It seems to the FL that the latest time at which the preamble can be retransmitted cannot be left to implementation.

vivo proposes that for NB-IoT, this relationship does not need enhancing because:

“it’s clear that the UE should retransmit PRACH in a NB-IoT uplink subframe between *t0* to *t0*+12ms where *t0* is the time of the end of subframe *n*. Based on the discussion in last meeting, UE-specific TA reporting is supported in IoT-NTN, eNB could be also aware of the timing relationship among these subframes where the UE may retransmit PRACH.”

The current specification says for example (TS 36.213 section 16.3.2) that:

 ‘ the UE shall be, ready to transmit a new preamble sequence **no later than the NB-IoT UL subframe starting 12 milliseconds** after the end of subframe *n*.’

In IoT NTN, PRACH retransmission is timing advanced. If the current TA is greater than 12ms, then we would be expecting the UE to retransmit the preamble before the end of subframe n – that is, before determining that there is need for a PRACH retransmission. Both Huawei/HiSilicon and vivo talk about the UE and eNB knowing the TA but this only has a bearing on this issue of non-causality if the argument is that preamble retransmission should not be timing advanced. This would be going against the previous agreement.

OPPO asks that the group first reaches an understanding on whether subframe n is on the DL or UL. The specification talks about ‘in the subframe *n* where it [the UE] expected to receive the RAR’. The subframe where the UE expects to receive the RAR is of course a DL subframe. In any case, the issue is with respect to the end time *t0* of the subframe – the preamble must be retransmitted by time *t0*+12ms (NB-IoT) and *t0*+4 or 5 subframe durations (eMTC).

It therefore seems that the limit of 12ms (NB-IoT) or 4/5 subframes (eMTC) for suitable ROs for PRACH retransmission has to be extended to allow the UE to use (and the eNB to search for) the right preamble format in ROs that lie beyond the 12ms (NB-IoT) or 4/5 subframes (eMTC) when the TA exceeds 12ms (NB-IoT) or 4/5 subframes (eMTC).

With this analysis, FL makes the following proposal and politely requests companies to indicate their support and comment accordingly.

FL Proposal 3.2.2-1

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

|  |  |  |
| --- | --- | --- |
| Company | Support/Not Support | Comments |
| SONY | Support | This timing relationship is defined for TN. We have to take into account that that PRACH is timing advanced for NTN. Hence, delaying the preamble retransmission slot by Koffset (to allow for the timing advance) is necessary.For eMTC, the proposal should refer to subframes rather than slots. Hence, the proposal could be updated as:**For IoT NTN, if the UE determines that a preamble retransmission is necessary, the choice of a suitable preamble retransmission slot / subframe shall be delayed by Koffset as compared to current specifications.** |
| Ericsson | Not Support | The description in section 16.3.2 of TS 36.213 for the timing relationship of preamble retransmission in NB-IoT TN is “no later than the NB-IoT UL slot starting 12 milliseconds after the end of subframe n” and thus can be reused for NB-IoT NTN. While the descriptions in section 6.1.1 of TS 36.213 for the timing relationship of preamble retransmission in eMTC TN are “no later than in subframe *n+5*” and “no later than in subframe *n+4*”, so the timing relationship of preamble retransmission in eMTC TN should be modified for eMTC NTN, for example the preamble retransmission should be delayed by Koffset as compared to current specifications. Therefore, we prefer to have separate proposals for NB-IoT and eMTC.For NB-IoT, for example, in section 16.3.2 of TS 36.213, one description is that “If no NPDCCH scheduling random access response is received in subframe *n*, where subframe *n* is the last subframe of the random access response window, the UE shall, if requested by higher layers, be ready to transmit a new preamble sequence no later than the NB-IoT UL slot starting 12 milliseconds after the end of subframe *n*.”, so the subframe *n* here means the last subframe of the random access response window in downlink as shown in the figure below. Therefore, the existing timing relationship in NB-IoT for the uplink preamble retransmission related to this subframe *n* can be reused for NB-IoT in NTN and no additional enhancement is needed.  |
| ZTE | Support | There’s no big difference between the descriptions of “12 milliseconds after the end of subframe n” and “no later than in subframe *n+5*”, and the only one is the gap of 4 subframe, so a unified solution for both NB-IoT and eMTC is preferred firstly.Then in order to align with previous agreements on many timing relationships, we think the “12 milliseconds after the end of subframe n” or “subframe n+5/ subframe n+4” can be identified as UL subframe for preamble retransmission, therefore introducing K\_offset is needed. |
| CATT | Support | We have made agreements for other timing relationships, like N/MPDCCH to PUSCH. According to previous discussions for other timing relationships, we have reached the consensus that the subframe where the UE expects to receive the N/MPDCCH or others is DL subframe n, and the subframe where the UE expects to transmit the PUSCH or others is UL subframe n. Hence, the received subframe n here for the preamble retransmission in NB-IoT and eMTC is DL subframe n. The transmitted subframe “12 milliseconds after the end of subframe n” or “subframe n+5/ subframe n+4” is UL subframe. Besides, to align NB-IoT and eMTC, K\_offset should be introduced in the preamble retransmission for both NB-IoT and eMTC. |
| Mavenir | Support | In our understanding, UE always applies TA to any specified UL transmission start time in the spec. So, we support consistency with other agreements on timing relationships regarding K\_offset, and using K\_offset for PRACH retransmission for both NB-IoT and eMTC. |
| Samsung | Support | Similar to other timing relationships already agreed. |
| Spreadtrum | Support |  |
| Nokia, NSB |  | Technically, it is clear for NB-IoT as “be ready to transmit a new preamble sequence no later than the NB-IoT UL slot starting 12 milliseconds after the end of subframe n.”. It means the retransmission is after the DL subframe n.For eMTC, the specification can also be updated as “be ready to transmit a new preamble sequence no later than in subframe .” “after the end of subframe n”In this case, UE can always take the TA into account and the spec is clear. |
| Lenovo, MotoM | Support | In our understanding, both the subframe n in “12 milliseconds after the end of subframe n” in NBIoT and “subframe n+5” in eMTC are Uplink subframe n, so K\_offset should be needed. |
| Qualcomm | Support for eMTC | As was extensively discussed in the GTW session, this change is needed for eMTC, due to the way the spec is written. For NB-IoT, it seems that current language is OK. |
| Huawei, HiSilicon | Not support for NB-IoT | We discussed this at the GTW, but we repeat our opinion for completeness. For terrestrial NB-IoT, NPRACH will not be timing advanced, 12ms delay provides sufficient time for UE to prepare a NPRACH retransmission. For NB-IoT over NTN, our understanding is that the 12ms delay is still the duration between the actual transmission timing of NPRACH and the DL timing of the end of subframe n. It is true that the NPRACH will be timing advanced in IoT-NTN but UE knows exactly how much NPRACH shall be timing advanced, it can still select a proper occasion for PRACH retransmission by taking into account effect of timing advanced applied at the UE.  |
| Xiaomi |  | For NB-IoT, as widely discussed during the GTW, the issue lays on how to interpreter the subframe n. If common understanding is it refers to a DL subframe, we are fine to accept that the Koffset is not needed for NB-IoT. |
| Nordic Semiconductor |  | We think that spec change is needed at least for eMTC. Clarification proposed by Nokia would be good for NB-IoT. And maybe similar wording could be used for eMTC.e.g. the UE shall be, if requested by higher layers, ready to transmit a new preamble sequence no later than 4 ms or 5 ms after the DL subframe *n*, based on different situations |
| CMCC | Support for eMTC | For NB-IoT, subframe n is a DL subframe, thus, delayed by Koffset seems not needed for NB-IoT. |
| vivo | Not Support | For NB-IoT, as shown in the figure, the UE should retransmit PRACH in a NB-IoT uplink subframe between the time of “fails to receive RAR” to the time of “complete preamble retransmission”, e.g., UL subframe n+12.  |
| GateHouse | Support with comment | There seemed to be some miscommunication on the time being defined in the UL or DL in the last GTW meeting. Given a DL timer, I think we all agree on the sequence:1. At $\left(N -\frac{RTT}{2}\right)$, eNB transmits PDCCH order.
2. At $(N)$, UE receives PDCCH order.
3. At $\left(N + k\_{2}, k\_{2}\leq 8\right)$, UE is ready to tx preamble.
4. At $\left(T\_{RAO}\geq N+k\_{2}\right), $ UE TXs preamble in RAO.
5. At $(T\_{RAO}+ RTT/2)$, eNB receives preamble in RAO.

The timing relationship for MSG1: $t\_{UL}=t\_{DL}+k\_{offset}$ The proposal is given in terms of $t\_{UL}$ while the current specifications are given in terms of $t\_{DL}$. Both are the same and fine either way. We agree with ZTE that a joint solution should be possible. |
| Apple | Support for eMTC | Based on the current specification of eMTC, we think the DL-UL transit is needed and Koffset is used. For NB-IoT, the current specification seems to define absolute duration, which is probably fine.  |

## PUSCH using PUR

This issue was discussed at RAN1#106e but without agreement and so FL made a recommendation proposing a list of issues on this topic that companies may study and bring contributions on at this meeting:

FL Recommendation

The enhancement of the timing relationship between NPUSCH/PUSCH and NPDCCH/MPDCCH UE-specific search space by PUR-RNTI

* whether there needs to be an update to the timing relationship (given Xingqin’s explanation for why not – summerised in Appendix A here)
* What other changes (e.g. the LEO issue, TA validation etc) are needed to support PUR in IoT NTN Rel16 and whether such changes **‘are not small’** as RAN2 puts it.

### FSS: other issues needing common understandingCompanies’ Observations and Proposals

|  |  |
| --- | --- |
| FGI, Asia Pacific Telecom, III, ITRI | Proposal 4: For LEO scenarios, PUR may be feasible during the period when UE has valid information about satellite ephemeris, GNSS, and common TA parameters in RRC\_IDLE. Proposal 5: PUR for NB-IoT over NTN shall be supported at least for the GEO scenario.Proposal 6: To support PUR in GEO-based NTN, if the UE has initiated an NPUSCH transmission using pre-configured uplink resource ending in subframe n, the UE shall monitor the NPDCCH UE-specific search space in a search space window starting in subframe n + 4 + K\_RTT, where K\_RTT is an estimate of UE-eNB RTT. |
| Samsung | **Proposal 3: For NB-IoT, for a NPUSCH transmission in pre-configured uplink resource ending in subframe *n*, the UE shall monitor the NPDCCH UE-specific search space with a delay of *k\_offset* as compared to transmission as per current specification.****Proposal 4: Support pre-configured uplink resource feature for IoT over NTN in Rel-17.** |
| Spreadtrum Communications | ***Proposal 3: For NB-IoT, if the UE has initiated an NPUSCH transmission using pre-configured uplink resource ending in subframe n, the time at which the UE shall start to monitor the NPDCCH UE-specific search space shall be delayed by UE-eNB RTT as compared to current specification.******Proposal 4: For eMTC, if the UE has initiated a PUSCH transmission using pre-configured uplink resource ending in subframe n, the time at which the UE shall start to monitor the MPDCCH UE-specific search space shall be delayed by UE-eNB RTT as compared to current specification.*****Target GEO b/c of fixed SAT** |
| OPPO | **Proposal 4: The feature of PUR depends on UE maintaining UL synchronization in idle mode, which does not seem to be tackled in AI 8.15.1. Thus, the whole feature of PUR may not be supported in R17. It is not recommended to only discuss timing relationship for PUR.**  |
| Nokia, Nokia Shanghai Bell | **Proposal 4: To support PUR in GEO deployments in release 17 and leave support for PUR for LEO as future work.** |
| CMCC | ***Proposal 4:*** For NB-IoT/eMTC, if PUSCH using PUR is to be supported and if the UE initiates an PUSCH transmission using pre-configured uplink resource ending in subframe n, the time at which the UE shall start to monitor the PDCCH UE-specific search space shall be delayed by the UE-eNB RTT as per current specification. |
| Lenovo, Motorola Mobility | ***Proposal 1: For NB-IoT/eMTC, if the UE has initiated an NPUSCH/PUSCH transmission using pre-configured uplink resource ending in subframe n, the time at which the UE shall start to monitor the NPDCCH/PDCCH UE-specific search space shall be delayed by Kmac  as compared to current specification. Kmac is the timing offset for DL & UL at eNB side and Kmac equals to 0 if DL & UL timing are aligned.*** |
| Intel | ***Proposal 4:*** ***• Support timing relationship enhancements to enable PUR for NTN******- K\_mac should be added for slot offset between PUR (N)PUSCH and (N)PDCCH******- Note: PUR is not supported for scenarios with delay changing over time (i.e. non-GEO satellites)*** |
| Sony | **Proposal 4: For NB-IoT, if the UE has initiated an NPUSCH transmission using pre-configured uplink resource ending in subframe n, the time at which the UE shall start to monitor the NPDCCH UE-specific search space shall be delayed by the UE-eNB RTT as compared to current specification.** **Proposal 5: For eMTC, if the UE has initiated a PUSCH transmission using pre-configured uplink resource ending in subframe n, the time at which the UE shall start to monitor the MPDCCH UE-specific search space shall be delayed by the UE-eNB RTT as compared to current specification.**  |
| ZTE | ***Proposal-1:*** *For NB-IoT/eMTC over NTN, start or restart of pur-ResponseWindowTimer should be delayed with K\_offset.* |
| Ericsson | ***Proposal 1: If the UE has initiated a PUSCH transmission using preconfigured uplink resource ending in uplink subframe n, the UE shall monitor the MPDCCH UE-specific search space by PUR-RNTI in a search space window starting in downlink subframe n+4+K\_mac with duration given by higher layer parameter pur-MPDCCH-SS-window-duration.*** ***Proposal 2: If the UE has initiated a NPUSCH transmission using preconfigured uplink resource ending in uplink subframe n, the UE shall monitor the NPDCCH UE-specific search space by PUR-RNTI in a search space window starting in downlink subframe n+4+K\_mac with duration given by higher layer parameter pur-SS-window-duration.*** ***Proposal 3: The granularity of K\_mac is subframe level.*** |

### FIRST ROUND Discussion on PUSCH using PUR

11 companies study and make observations and proposals on this issue. The proposals fall in 3 classes:

* No support of PUR in Rel17 IoT NTN: OPPO
* Support PUR in Rel17 IoT NTN : Samsung, Sony, ZTE, Ericsson, Lenovo&MM, CMCC
* Support PUR only for GEO in Rel17 IoT NTN: FGI, Spreadtrum, Nokia, Intel

Having considered the varying TA issue, 4 companies propose that PUR be supported for GEO where the TA is relatively static. 6 other companies think PUR should be supported in Rel17. So, the overwhelming majority of companies that studied this issue (10 out of 11) think that PUR should be supported somewhat. One company OPPO rightly highlights that there are other issues beyond time-relationship enhancement to be discussed. FL comment: some of these issues are being discussed in RAN2. In this AI, the issue on the table is timing relationship enhancement so FL thinks since it has been raised by companies, we should discuss and conclude on it.

Based on this, FL makes the following proposals and urges companies to express their views.

FL Proposal 3.3.2-1:

If PUR is supported for NB-IoT, then if the UE has initiated an NPUSCH transmission using pre-configured uplink resource ending in subframe n, the time at which the UE shall start to monitor the NPDCCH UE-specific search space shall be delayed by the UE-eNB RTT as compared to current specification.

|  |  |  |
| --- | --- | --- |
| Company | Support/Not Support | Comments |
| SONY | Support | Maybe we could try to agree the timing relationship for PUR as a working assumption. The working assumption could be confirmed if PUR is supported. The working assumption would then be:For NB-IoT, if the UE has initiated an NPUSCH transmission using pre-configured uplink resource ending in subframe n, the time at which the UE shall start to monitor the NPDCCH UE-specific search space shall be delayed by the UE-eNB RTT as compared to current specification.  |
| Ericsson | Support but modification is needed. | UE-eNB RTT is the sum of TA and K\_mac, so the downlink subframe n + 4 + K\_mac is the downlink subframe starting UE-eNB RTT after the ending of uplink subframe n + 4. Since the UE needs to monitor the NPDCCH UE-specific search space in downlink, it will be clearer to use the description of downlink subframe n + 4 + K\_mac for the timing relationship of PUSCH using PUR directly. |
| ZTE |  | W.r.t the use case of PRU, we prefer to support it in NTN. We are also fine to agree it as a working assumption.For the exact timing relationship, one more case is need based on the description in TS 36.331, i.e. start/restart to monitor the NPDCCH UE-specific search space...In our view, the enhancement is needed basically because of the delay of eNB UL timeline (when RP is the satellite). In this situation, the eNB should defer the transmission of NPDCCH (transmit after receiving NPUSCH transmission), so only K\_mac is taken as the delay, but not UE-eNB RTT. |
| OPPO | Not Support | The UE maintaining synchronization in idle mode does not seem to be discussed. In this case, in our view, even the timing relationship for PUR is addressed, this PUR feature cannot fly for R17. So we suggest to postpone the enhancement for PUR to the next release.  |
| CATT | FFS | For the UE has a NPUSCH/PUSCH transmission using PUR ending in UL subframe n, the UE shall monitor the N/MPDCCH in DL subframe n+4+K\_mac. |
| Mavenir | Support | We also support explicit description of downlink subframe n + 4 + K\_mac for the timing relationship of PUSCH for PUR, because the time difference between UL subframe n and DL subframe n+K\_mac is equal to UE-eNB RTT.Also, it seems that there has been no agreement on introducing K\_mac in IoT NTN (which is needed to complete the spec for IoT NTN). We suggest to re-use the relevant NR NTN agreements on K\_mac as much as possible. |
| MediaTek | Support with modification | Modification may be needed with downlink subframe n + 4 + K\_mac for the timing relationship of PUSCH using PUR directly as mentioned by Ericsson.On OPPO comment, PUR is a natural feature for IoT NTN as the UE will have a valid TA based on UE-specific TA and common TA when it decides to transmit data during idle. It should not be issue for UE to acquire ephemeris and common TA parameters in idle to support PUR, as this is no different from normal case where UE needs to prepare for UE pre-compensation for UL synchronization before initiating random access procedure. |
| Samsung | Support | We are fine with an explicit description of the additional delay to be added in the UL-DL timing relationship, and also support to agree on the definitions of the timing quantities (as in NR NTN).Supporting the PUR feature for NTN seems straightforward – UE needs to have a valid TA when transmitting in pre-configured uplink resources and adjust the timing relationship currently under discussion.  |
| Spreadtrum | Support |  |
| Nokia, NSB | Support | We are fine to support PUR for GEO cases for IoT NTN in Rel17. Where the delay after ending of UL repetition before starting monitoring PDCCH should be added to define UE behavior.As it is from UL to DL, K\_mac should be considered as the delay instead of UE-eNB RTT. |
| Lenovo, MotoM | Support with modification | Share the similar view as E///, Mavenir and MediaTek |
| Qualcomm | Only need K\_mac update | As we have described in the GTW sessions, whenever the specs talk of “reception”, it refers to downlink timing, and whenever it talks of “transmission”, it refers to uplink timing.As a result, in a “K\_mac-free” world, we wouldn’t need any change. However, since K\_mac may be different from 0, the proposal from Ericsson is OK (without any need to insert DL or UL, since this is universal understanding). |
| Huawei, HiSilicon | Fine to support | Agree with Ericsson that K\_mac shall be taken into account. |
| CMCC | Support | Agree with Ericsson, CATT, etc. that K\_mac should be considered as the delay instead of UE-eNB RTT. |
| GateHouse | Support | Fine with PUR and the proposed working assumption with final modifications to PUR as FFS. |
| Novamint | Support  | Agree with Sony |
| Apple | Support with modification | Agree with Ericsson and other companies that K\_mac is included.  |

FL Proposal 3.3.2-2:

If PUR is supported for for eMTC, then if the UE has initiated a PUSCH transmission using pre-configured uplink resource ending in subframe n, the time at which the UE shall start to monitor the MPDCCH UE-specific search space shall be delayed by the UE-eNB RTT as compared to current specification.

|  |  |  |
| --- | --- | --- |
| Company | Support/Not Support | Comments |
| SONY | Support | Maybe we could try to agree the timing relationship for PUR as a working assumption. The working assumption could be confirmed if PUR is supported. The working assumption would then be:For eMTC, if the UE has initiated an NPUSCH transmission using pre-configured uplink resource ending in subframe n, the time at which the UE shall start to monitor the NPDCCH UE-specific search space shall be delayed by the UE-eNB RTT as compared to current specification.  |
| Ericsson | Support but modification is needed. | UE-eNB RTT is the sum of TA and K\_mac, so the downlink subframe n + 4 + K\_mac is the downlink subframe starting UE-eNB RTT after the ending of uplink subframe n + 4. Since the UE needs to monitor the MPDCCH UE-specific search space in downlink, it will be clearer to use the description of downlink subframe n + 4 + K\_mac for the timing relationship of PUSCH using PUR directly. |
| ZTE |  | Similar as FL Proposal 3.3.2-1: |
| OPPO | Not Support | The UE maintaining synchronization in idle mode does not seem to be discussed. In this case, in our view, even the timing relationship for PUR is addressed, this PUR feature cannot fly for R17. So we suggest to postpone the enhancement for PUR to the next release.  |
| CATT | FFS | For the UE has a NPUSCH/PUSCH transmission using PUR ending in UL subframe n, the UE shall monitor the N/MPDCCH in DL subframe n+4+K\_mac. |
| Mavenir | Support | We also support explicit description of downlink subframe n + 4 + K\_mac for the timing relationship of PUSCH for PUR, because the time difference between UL subframe n and DL subframe n+K\_mac is equal to UE-eNB RTT.Also, it seems that there has been no agreement on introducing K\_mac in eMTC NTN (which is needed to complete the spec for eMTC NTN). We suggest to re-use the relevant NR NTN agreements on K\_mac as much as possible. |
| Samsung | Support | Same considerations as for PUR for NB-IoT. |
| Spreadtrum | Support |  |
| Nokia, NSB | Support | We are fine to support PUR for GEO cases for IoT NTN in Rel17. Where the delay after ending of UL repetition before starting monitoring PDCCH should be added to define UE behavior.As it is from UL to DL, K\_mac should be considered as the delay instead of UE-eNB RTT. |
| Lenovo, MotoM | Support with modification | Similar comments as PUR for NBIoT |
| Qualcomm | Only need K\_mac update | As we have described in the GTW sessions, whenever the specs talk of “reception”, it refers to downlink timing, and whenever it talks of “transmission”, it refers to uplink timing.As a result, in a “K\_mac-free” world, we wouldn’t need any change. However, since K\_mac may be different from 0, the proposal from Ericsson is OK (without any need to insert DL or UL, since this is universal understanding). |
| CMCC | Support | Same considerations as for PUR for NB-IoT that K\_mac should be considered as the delay instead of UE-eNB RTT. |
| Novamint | Support | Same as for NB |
| Apple | Support with modification | Agree with Ericsson and other companies that K\_mac is included.  |

FL Proposal 3.3.2-3:

Support PUR at least for GEO-based IoT NTN in Rel17

|  |  |  |
| --- | --- | --- |
| Company | Support/Not Support | Comments |
| SONY | Support | We could add “FFS: LEO”.This could be discussed as part of the UE Features discussion. |
| Ericsson |  | We prefer to support PUR for both GEO and non-GEO cases. |
| ZTE |  | We prefer to support PUR for both GEO and non-GEO cases. |
| OPPO |  | We suggest to postpone the enhancement for PUR to the next release. |
| MediaTek |  | We prefer to support PUR for both GEO and non-GEO cases. This could be compromise if support of PUR with LEO was shown to be significantly more impact on specifications. |
| Samsung |  | Unless it is found that further enhancements are needed for LEO, it is preferable to support PUR for both GEO and LEO. |
| Spreadtrum | Support |  |
| Nokia, NSB | Support | We suggest to support PUR in GEO in Rel 17. Support for LEO is challenging due to change of serving cell and changing radio conditions while it could be a topic for Rel 18. |
| Lenovo, MotoM |  | We prefer to support PUR for both GEO and non-GEO cases. |
| Qualcomm | Support for GEO | [Seems a far-cry to support for LEO, e.g., if serving satellite changes between PUR occasions, etc.] |
| Huawei, HiSilicon | Partly support | GEO is close to the terrestrial very low mobility NB-IoT case and we can understand the argument that PUR could provide benefit there. We do not see any reason to keep the LEO case open, and propose to remove “at least”. If the group intend to discuss the support of PUR for LEO, it would better to have separate discussion on the TA validation mechanism taking into account GNSS validity as well as the UL synchronization validity timers for satellite ephemeris and common TA (if supported). |
| Nordic Semiconductor | Support for GEO |  |
| GateHouse | Support | We prefer to support PUR for both GEO and non-GEO cases. |
| Novamint |  | We would prefer to support PUR for both GEO and non-GEO cases as pointed by many other companies. If found that there are significant more impacts on the specifications for LEO, we could then reduce this to GEO. |
| Apple | Support |  |

## NPDCCH Monitoring Restrictions

In NTN, the TA is large enough to change the subframes on which NPDCCH monitoring is restricted. In TN, these restrictions are specified for example (section 16.6 of TS36.213) as:

If a NB-IoT UE detects NPDCCH with DCI Format N1 ending in subframe *n*, and if the corresponding NPDSCH transmission starts from *n+k,* and

- for FDD, if the corresponding NPUSCH format 2 transmission starts from subframe *n+m* the UE is not required to monitor NPDCCH in any subframe starting from subframe *n+ k* to subframe *n+m-1*.

The subframes restricted for NPDCCH monitoring ought to be those immediately preceding the subframe in which the NPUSCH format 2 is to be transmitted after being subjected to timing advance. In TN, because the TA is typically a tiny proportion of the subframe duration, timing advance of UL transmissions rarely changes the scheduled subframe or slot of the UL transmission. For this reason, restrictions on NPDCCH monitoring just prior to the UL transmissions do not take into account the TA in current specifications. In NTN, the TA can be tens of times the subframe duration. Companies studied this issue.

### Companies’ Observations and Proposals

|  |  |
| --- | --- |
| OPPO | **Observation 1: the legacy NPDCCH monitoring restriction may be not be suitable for NTN system due to the change of scheduling time relationship.** **Proposal 6: RAN1 should discuss if the legacy NPDCCH monitoring restriction is still valid.** |
| Qualcomm | ***Proposal 3*: The definition of downlink interrupted subframes (e.g., those before and after a PUSCH, PRACH, PUCCH, and half-duplex guard periods), where a half-duplex UE is not expected to monitor PDCCH, is modified, in accordance with the large UE-specific TAs in NTN.** |
| vivo | ***Observation 1: In IoT NTN, the current specification for NPDCCH monitoring restrictions of UL transmissions should be modified.******Proposal 4: Support to introduce K\_TA for current restrictions on NPDCCH monitoring of UL transmissions,*** ***where the unit of K\_TA is subframe and the value of K\_TA is derived from TA in UE side.*** |
| ZTE | ***Proposal-11:*** *Necessary adaption of timing is needed for interrupted downlink/Guard subframes.* |

### FIRST ROUND Discussion on PDCCH Monitoring Restrictions

Four companies make proposals on modification of NPDCCH monitoring restrictions. According to previous RAN1 agreements on IoT NTN, the transmission time of an NPUSCH format 2 scheduled in subframe n+k would first be delayed through timing relationship enhancement to n+k+*K\_offset* and then timing advanced to n+k+*K\_offset* -TA. If *K\_offset* is equal to TA, then the NPUSCH format 2 would actually be transmitted in subframe n+k. However, this cannot always be guaranteed. In deciding the subframes that should be restricted for NPDCCH monitoring therefore, we should be concerned with the subframe in which the NPUSCH format 2 is actually transmitted after timing relationship enhancement and timing advance and not the subframe in which it was scheduled.

 FL invites companies to make their views known in the following survey.

FL Survey 3.4.2-1:

Given the explanation above, do you see the need for change in the designation of subframes that should be restricted for NPDCCH monitoring in the specification for IoT NTN? If yes, please propose an agreement.

|  |  |  |
| --- | --- | --- |
| Company | Change/Not Changed | Comments and Proposal |
| SONY | Change | The specifications need to account for the timing relationship enhancement (extension by Koffset).We should start off by identifying which timing relationships have “interrupted subframe” specification. We can then determine whether there needs to be a specification update for each identified timing relationship. |
| ZTE | Change | We agree with SONY’s comments above. In addition, for timing relationship of DCI scheduled NPUSCH (as described in TS 36.213/16.6), in our view, at least for two HARQ-Processes, introduce K\_offset to maintain the timing between the UL transmission of 1st HARQ process and potential PDCCH reception of 2nd HARQ process. |
| OPPO | Not change | In our view, the restriction of the PDCCH monitoring should be discussed separately as follows:1. the PDCCH monitoring in UL;
2. the PDCCH monitoring in DL;
3. the PDCCH monitoring in HARQ process.

Different solutions correspond to different situations. |
| MediaTek | Change may be needed | Details can be further discussed in RAN1 |
| Lenovo, MotoM | Change | We should update the NPDCCH monitoring restriction due to large value of TA in NTN. The interrupted subframes in NTN NBIoT is different from that in TN NBIoT. |
| Qualcomm | Change needed | As we have highlighted in several contributions (with diagrams), the specs need modification for interrupted subframe definitions, on account of the large TA in NTN.To being with, we can try along the lines of our proposal (others can modify), for an agreement:***Potential Agreement:****“****The definition of downlink interrupted subframes—i.e., those before and after a PUSCH, PRACH, PUCCH, and half-duplex guard periods)—where a half-duplex eMTC/NB-IoT UE is not expected to monitor PDCCH, needs to be modified, in accordance with the UE-specific TAs in NTN”.*** |
| Huawei, HiSilicon | Not changed | The enhancement on PDCCH monitoring has been discussed previously and it was concluded that with the introduction of TA reporting and the UE-specific K\_offset, we are not sure whether there is a need to introduce a duplicated function.  |
| Nordic Semiconductor | Changes are needed | We agree with SONY’s comments above. In addition, we think that eMTC half-duplex operation shown below may need spec changes. Spec changes could be implemented according to the first proposal in our contribution.From 36.211 sec. 6.2.5“For type B half-duplex FDD operation, guard periods, each referred to as a half-duplex guard subframe, are created by the UE by- not receiving a downlink subframe immediately preceding an uplink subframe from the same UE, and- not receiving a downlink subframe immediately following an uplink subframe from the same UE.” |
| CMCC | Not changed | We share the same view with Huawei that with the introduction of TA reporting and the UE-specific K\_offset, K\_offset – TA may be less than 1 subframe. Thus, enhancement may be not needed. |
| vivo | Change | For NPDCCH monitoring restrictions on UL transmissions, the UE is not required to monitor an NPDCCH candidate in some subframes, those subframes is advanced by K\_TA as compared to current specification, the unit of K\_TA is subframe and the value of K\_TA is derived from TA in UE side. |
| GateHouse | Change | Agree with SONY. |
| Novamint  | Change needed | Agree with Sony |
| Apple | Change | The timing relationship enhancement (e.g., via Koffset) may be introduced.  |

# K\_offset handling

###  Companies’ Observations and Proposals

|  |  |
| --- | --- |
| Mavenir | ***Observation 1:*** *The following relationship should hold for the value of* $K\_{offset,cell-specific}$*:* $K\_{offset,cell-specific}×10^{-3}\geq $ *The largest possible* $T\_{TA}$ *in the cell.****Proposal 1:*** *The* $K\_{offset,cell-specific}$ *for IoT-NTN is transmitted in SIB.****Observation 2:*** *The following relationship should hold for the value of* $K\_{offset,UE-specific}$*:*$K\_{offset,UE-specific}×10^{-3}\geq $$T\_{TA}$ *of the UE in RRC\_CONNECTED state.****Proposal 2:*** *In RRC\_CONNECTED state, if the UE is not configured with UE-specific K\_offset, it uses the cell-specific K\_offset.* |
| MediaTek | ***Observation 1****: The UE-specific differential K\_offset has lower overhead that the UE-specific K\_offset with low overhead and low frequency of update:* * *UE-specific differential K\_offset with granularity of 2 slots scaled by a factor 2µ has an overhead of 3 bits for LEO@600 km and 4 bits for LEO@1200 km, and 3 bits for GEO@35786 km.*
* *UE-specific differential K\_offset with granularity of 3 slots scaled by a factor 2µ has an overhead of 2 bits for GEO@35786 km.*
* *The maximum UE-specific differential K\_offset total overhead within* a maximum LEO satellite coverage time of 2 minutes *is 16 bits.*
* *For LEO@600 km and LEO@1200 km, the K\_offset can be updated at most once per 22 seconds and once per 33 seconds respectively.*
* *For GEO, it may not be necessary to update the K\_offset as it only needs to be updated at most every 391 seconds. The overhead is not significant.*

***Proposal 1:*** *The UE-specific differential K\_offset determined as the difference between the cell-specific K\_offset and the UE-specific K\_offset is indicated by MAC CE.* |
| CATT | **Proposal 3: The UE-specific K\_offset can be provided and updated at least by network with MAC CE.** |
| Apple | *Proposal 3:* *• Consider the following options for K\_offset indication* *o Alt. 1: Single K\_offset value is indicated* *o Alt. 2: Two K\_offset values corresponding to service link and feeder link are indicated separately** FFS: Joint determination of K\_offset, Common TA and K\_mac* |
| Intel | **Proposal 5:** **• The same ignaling design for UE-specific K\_offset is used for IoT NTN and NR NTN** **- UE-specific K\_offset is indicated via MAC CE****- Indication of difference between cell-specific K\_offset and UE-specific K\_offset can be considered** |
| ZTE | ***Proposal-4:*** *Reuse the ignaling mechanism on indication/updates of K\_offset and/or Kmac concluded in NR-NTN.* |
| Apple | ***Proposal 3:*** *In IoT over NTN, the unit of* $K\_{offset}$ *is subframe in 15 kHz subcarrier spacing.* ***Proposal 4:*** *In IoT over NTN, the UE specific* $K\_{offset}$ *is provided and updated by network with MAC CE.*  |
| Nordic Semiconductor ASA | ***Proposal-2:*** *Cell-specific* $K\_{offset,common}$ *is at least indicated in SIB1*  |

### FIRST ROUND Discussion on K\_offset Handling

The 8 companies that made proposals on K\_offset handling cover the following issues:

* Granularity of K\_Offset
* Indication and update of UE-specific K\_Offset,

Many of these issues have either been agreed or are being discussed in NR NTN. FL does not see any specificities of IoT NTN that warrant different decisions on these aspects of K\_offset handling. Therefore, FL makes the following proposal which companies are invited to comment upon.

FL Proposal 4.1.2-1:

For IoT NTN, with respect to the granularity, configuration, indication and update of K\_Offset, reuse the mechanisms concluded in NR-NTN.

|  |  |  |
| --- | --- | --- |
| Company | Support/Not Support | Comments |
| SONY | Support |  |
| Ericsson | Support |  |
| ZTE | Support |  |
| OPPO | Support |  |
| CATT | Partial support | For configuration, indication and update of K\_Offset, the conclusions can be reused, while for the granularity, utilize ms or subframe as the unit is better. |
| Mavenir | Support |  |
| MediaTek | Support | Some adjustments may be needed to reflect the larger beam size of 1700 km for IoT NTN  |
| Samsung | Support |  |
| Spreadtrum | Support |  |
| Nokia, NSB | Support |  |
| Huawei, HiSilicon | Support |  |
| Xiaomi |  | It is better we make agreements for each issues directly rather than to simply say we follow the NTN design. |
| CMCC | Support |  |
| vivo | Support |  |
| GateHouse | Support, but | Support, but potential for re-evaluation once NR NTN has come to a decision if any use cases – e.g., (very) low earth orbits for smallsats - are not covered. |
| Novamint | Support | Agree as well with the point made by GateHouse as there could be a need for revision |
| Apple | Support | Some adjustments (e.g., value range) might be needed considering the different subcarrier spacings between LTE and NR.  |

# UE-specific TA Handling

Issues needing study and discussion covered in company contributions include:

* The quantity to report with the following options under consideration:
	+ **Option 1:** UE-specific NTA, UE-specific – service link TA
	+ **Option 2:** UE-specific full TA applicable to UL transmission – (service + feeder link TA)
	+ **Option 3:** UE location
	+ **Option 4:** Difference between UE-specific K\_offset and cell-specific K\_offset
	+ **Option 5:** Difference between the last applied K\_offset (e.g., cell-specific K\_offset or UE-specific K\_offset indicated by the network) and one new K\_offset suggested by UE
	+ **Option 6:** Differential indication
	+ **Option 7:** Reporting of a stationarity indication + Option 1 or Option 2

FFS whether to down select including combining options

* Signaling overhead
* Granularity of report
* Frequency of reporting
* Means of reporting

## Quantity to Report

###  Companies’ Observations and Proposals

|  |  |
| --- | --- |
| Huawei | ***Observation 2:*** *Either reporting UE-specific NTA, UE-specific or UE-specific full TA, the overhead are very large if they are applied for each reporting instance.****Observation 3:*** *By reporting UE location, the validity of UE-specific TA calculation in long UL transmission is not a concern as its value can be maintained by eNB.****Proposal 3:*** *For IoT-NTN, differential indication with granularity of one slot is adopted for UE-specific K\_offset update.****Proposal 4:*** *For UE moving at high speed, a coarse location can be reported for UE-specific TA and a differential value with granularity of one slot can be reported for UE-specific TA update.* ***Proposal 5:*** *For UE-specific TA indication, support the combination reporting of a stationarity indication and differential TA compared to the last report.* |
| Spreadtrum Communications | **Proposal 1: For UE-specific TA reporting, UE only need to report UE-specific NTA, UE-specific related information (i.e., RTT between UE and satellite).** |
| MediaTek Inc. | ***Observation 2****: For initial access, the UE-specific full TA seems a good choice since the UE anyway calculate the UE-eNB RTT to delay start of RAR window. The UE-specific full TA is effectively the UE-eNB RTT. This ensures UE and eNB have same understanding on the feeder link part of the full TA.****Proposal 4****: NB-IoT NTN can re-use Rel-15 UE differentiation feature for indication of stationarity.*  |
| CATT | **Proposal 6: Reporting differential TA between current TA and previous TA is preferred.** |
| Qualcomm | ***Proposal 1*: A UE reports the UE-specific TA to the network when the previously reported value differs from a current value by a pre-determined threshold.**  |
| Nokia, Nokia Shanghai Bell | **Observation 7: The UE location report is utilized by RAN2 and RAN3 for NTN****Proposal 2: Reporting UE location for determining UE-specific Timing Advance in half duplex deployments is one method, which can be used by eNB scheduler to avoid UL-DL collisions.****Proposal 3: As UE location reporting is already agreed and utilized in RAN2 and RAN3 for multiple purpose, UE location reporting should be specified for IoT NTN in Rel 17.** |
| OPPO | **Proposal 1: Support reporting UE specific TA or full-TA.** |
| CMCC | ***Proposal 5:*** For UE reporting of information about the UE specific TA pre-compensation, at least one of the following options is supported.* Option 3: UE location.
* Option 4: Difference between UE-specific K\_offset and cell-specific K\_offset.
* Option 5: Difference between the last applied K\_offset (e.g., cell-specific K\_offset or UE-specific K\_offset indicated by the network) and one new K\_offset suggested by UE.
 |
| Xiaomi | ***Proposal 3: At least for uplink scheduling adaptation, the exact content of UE reporting of information about the UE specific TA pre-compensation is UE specific TA and a differential indication is preferred.*** |
| Intel | Proposal 2: Support one of the following alternatives to decrease UE-specific TA reporting overhead* Alt 1. Reporting of information to extrapolate/interpolate UE-specific TA

E.g. series of values with differential encoding scheme* Alt 2. Reporting of UE location (based on GNSS)
 |
| Sony | **Proposal 6: For IoT NTN, the UE should report its UE location rather than the UE-specific TA itself.** |
| ZTE | ***Proposal-6:*** *At least the report of the full applied TA for UL transmission should be supported in the first report.* ***Proposal-7:*** *For the subsequent TA reporting if required in IoT case with short transmission, indication of differential value (e.g., via one bit) can be considered to reduce the signalling overhead.* ***Proposal-8:*** *In case of segment pre-compensation, the latest TA value applied for the last segment should be reported.* |
| Lenovo, Motorola Mobility | ***Proposal 2: UE report the TA value in msg3 and report the TA value in the following NPUSCH, the TA can be propagation delay***/***UE-specific TA (reflecting all or partial of round-trip delay) (e.g., one way delay, excluding the feeder link delay).******Proposal 3: Differential TA value can be reported in msg3 or NPUSCH and the differential TA can be the relative value to 1) broadcast common TA; 2) configured cell specific Koffset; 3) (previous) reported TA.*** |
| FGI, Asia Pacific Telecom, III, ITRI | Proposal 1: Contents of UE-specific TA report shall wait for the outcome of the LS to SA3 to ensure whether user consent for obtaining UE location by gNB is needed.**Proposal 2:** For UE-specific TA report, RAN2#115-e agreements in NR over NTN shall be reused, e.g., under the work assumption "the UE location information cannot be reported in connected mode", the content of UE specific TA reported in connected mode is UE specific TA pre-compensation. |
| Ericsson | Proposal 4: The mechanism for UE specific TA maintenance and reporting can follow the decision in NR\_NTN\_Solutions WI and reuse the agreements therein for IoT NTN with minimum changes if any. |
| Apple | ***Proposal 5:*** *For UE specific TA reporting, the contents of report are differential UE specific TA or differential UE’s full TA with coarse granularity (e.g., subframe-level granularity).* ***Proposal 7:*** *For UE-eNB RTT estimation, information of* $K\_{mac}$ *is carried in system information. The unit of* $K\_{mac}$ *is subframe in 15 kHz subcarrier spacing.* |
| Nordic Semiconductor ASA | ***Proposal-3:*** *UE reports its UE-specific TA at least in MSG3 and eNB configures UE-specific* $K\_{offset,UE}$ *that is larger than total TA at least in MSG4.* |

## The granularity of the reported quantity

###  Companies’ Observations and Proposals

|  |  |
| --- | --- |
| Huawei | ***Observation 4:*** *The calculation latency of eNB is not a major issue, since the UE-specific TA is mainly used for scheduling where granularity is one slot.****Observation 6:*** *For UE location reporting, a coarse indication is sufficient.****Proposal 2:*** *For stationary or low speed UE, the UE reports a coarse location for calculation of UE specific TA at the gNB side.****Proposal 3:*** *For IoT-NTN, differential indication with granularity of one slot is adopted for UE-specific K\_offset update.****Proposal 4:*** *For UE moving at high speed, a coarse location can be reported for UE-specific TA and a differential value with granularity of one slot can be reported for UE-specific TA update.*  |
| Spreadtrum Communications | **Proposal 2: The granularity of reporting UE-specific NTA, UE-specific should be same as the granularity of K\_offset.** |
| MediaTek Inc. | ***Observation 3****: The granularity and frequency of UE-specific differential TA report is of same order than that for the UE-specific differential K\_offset update – i.e.** *UE-specific differential TA report with granularity of 2 slots scaled by a factor 2µ has an overhead of 3 bits for LEO@600 km and 4 bits for LEO@1200 km, and 3 bits for GEO@35786 km.*
* *UE-specific differential TA report with granularity of 3 slots scaled by a factor 2µ has an overhead of 2 bits for GEO@35786 km.*
* *The maximum UE-specific differential TA report total overhead within* a maximum LEO satellite coverage time of 2 minutes *is 16 bits.*
* *For LEO@600 km and LEO@1200 km, the UE TA report can be updated at most once per 22 seconds and once per 33 seconds respectively.*
* *For GEO, it may not be necessary to update the TA report as it only needs to be updated at most every 391 seconds. The overhead is not significant.*
 |
| CATT | **Proposal 8: Utilize ms or subframe as the unit of reported TA.** |
| Nokia, Nokia Shanghai Bell | **Observation 6: Defining a TA reference, based on UE location, can minimize signalling overhead, because network and UE can both predict TA. UE only needs to report if it has moved.** |
| OPPO | **Proposal 3: The granularity for reported information is slot.** |
| Intel | Proposal 1: Coarse granularity can be considered for reporting of UE-specific TA (e.g. one subframe or slot) |
| Apple | ***Proposal 5:*** *For UE specific TA reporting, the contents of report are differential UE specific TA or differential UE’s full TA with coarse granularity (e.g., subframe-level granularity).*  |

## Signaling overhead

### Companies’ Observations and Proposals

|  |  |
| --- | --- |
| Huawei | ***Observation 2:*** *Either reporting UE-specific NTA, UE-specific or UE-specific full TA, the overhead are very large if they are applied for each reporting instance.*Observation 5: For a stationary or low speed UE, calculating UE specific TA at the network side could save the signalling overhead and UE complexity. |
| MediaTek Inc. | ***Observation 3****: The granularity and frequency of UE-specific differential TA report is of same order than that for the UE-specific differential K\_offset update – i.e.** *UE-specific differential TA report with granularity of 2 slots scaled by a factor 2µ has an overhead of 3 bits for LEO@600 km and 4 bits for LEO@1200 km, and 3 bits for GEO@35786 km.*
* *UE-specific differential TA report with granularity of 3 slots scaled by a factor 2µ has an overhead of 2 bits for GEO@35786 km.*
* *The maximum UE-specific differential TA report total overhead within* a maximum LEO satellite coverage time of 2 minutes *is 16 bits.*
* *For LEO@600 km and LEO@1200 km, the UE TA report can be updated at most once per 22 seconds and once per 33 seconds respectively.*
* *For GEO, it may not be necessary to update the TA report as it only needs to be updated at most every 391 seconds. The overhead is not significant.*

***Observation 4****: Report of UE-specific location with 23 bits is comparable to the total UE-specific differential TA overhead of 16 bits within time the UE is in coverage of satellite of up to 2 minutes.* ***Observation 5****: Because of low update rate of UE-specific TA report, there seems to be no significant gain in signalling overhead if UE location report is used.* The *complexity and security issues associated with reporting, processing, and latency of UE location in the core network also need to be taken into account.* |
| CATT | **Proposal 6: Reporting differential TA between current TA and previous TA is preferred.** |
| Nokia, Nokia Shanghai Bell | **Observation 1: Reporting each UE specific Timing Advance change leads to high uplink signalling load and power consumption, even for stationary UE.****Observation 2: for stationary UE, frequency of TA reporting will be much larger, e.g. 6-11 times in some cases, than for Location reporting.****Observation 3: for moving UE, frequency of TA reporting will also be much larger than location reporting, considering the relative slow speed of UE compared to the satellite.** **Observation 6: Defining a TA reference, based on UE location, can minimize signalling overhead, because network and UE can both predict TA. UE only needs to report if it has moved.** |
| OPPO | **Proposal 3: The granularity for reported information is slot.** |
| Intel | Proposal 2: Support one of the following alternatives to decrease UE-specific TA reporting overhead* Alt 1. Reporting of information to extrapolate/interpolate UE-specific TA

E.g. series of values with differential encoding scheme* Alt 2. Reporting of UE location (based on GNSS)
 |
| ZTE | ***Proposal-7:*** *For the subsequent TA reporting if required in IoT case with short transmission, indication of differential value (e.g., via one bit) can be considered to reduce the signalling overhead.*  |
| Apple | ***Proposal 6:*** *Support at least event triggered TA reporting.*  |

## Frequency of reporting

### Companies’ Observations and Proposals

|  |  |
| --- | --- |
| Huawei | ***Observation 5:*** *For a stationary or low speed UE, calculating UE specific TA at the network side could save the signalling overhead and UE complexity.****Proposal 5:*** *For UE-specific TA indication, support the combination reporting of a stationarity indication and differential TA compared to the last report.****Proposal 6:*** *UE request TA reporting resources based on its speed to help eNB configure semi-static resource for differential TA reporting* |
| MediaTek Inc. | ***Observation 3****: The granularity and frequency of UE-specific differential TA report is of same order than that for the UE-specific differential K\_offset update – i.e.** *UE-specific differential TA report with granularity of 2 slots scaled by a factor 2µ has an overhead of 3 bits for LEO@600 km and 4 bits for LEO@1200 km, and 3 bits for GEO@35786 km.*
* *UE-specific differential TA report with granularity of 3 slots scaled by a factor 2µ has an overhead of 2 bits for GEO@35786 km.*
* *The maximum UE-specific differential TA report total overhead within* a maximum LEO satellite coverage time of 2 minutes *is 16 bits.*
* *For LEO@600 km and LEO@1200 km, the UE TA report can be updated at most once per 22 seconds and once per 33 seconds respectively.*
* *For GEO, it may not be necessary to update the TA report as it only needs to be updated at most every 391 seconds. The overhead is not significant.*

***Observation 4****: Report of UE-specific location with 23 bits is comparable to the total UE-specific differential TA overhead of 16 bits within time the UE is in coverage of satellite of up to 2 minutes.* ***Observation 5****: Because of low update rate of UE-specific TA report, there seems to be no significant gain in signalling overhead if UE location report is used.* The *complexity and security issues associated with reporting, processing, and latency of UE location in the core network also need to be taken into account.* |
| CATT | **Proposal 4: For UE\_specific TA reporting, both event triggered and periodic methods should be supported.** |
| Qualcomm | ***Proposal 1*: A UE reports the UE-specific TA to the network when the previously reported value differs from a current value by a pre-determined threshold.** ***Proposal 2*: The UE-specific TA is reported in an uplink semi-persistent scheduling (UL-SPS) message, such as the one used for reporting buffer status reports (BSRs) in NB-IoT.** |
| Nokia, Nokia Shanghai Bell | **Observation 1: Reporting each UE specific Timing Advance change leads to high uplink signalling load and power consumption, even for stationary UE.****Observation 2: for stationary UE, frequency of TA reporting will be much larger, e.g. 6-11 times in some cases, than for Location reporting.****Observation 3: for moving UE, frequency of TA reporting will also be much larger than location reporting, considering the relative slow speed of UE compared to the satellite.**  |
| OPPO | **Proposal 2: Support UE requesting K offset update to the network in an event triggered manner.** |
| Intel | Proposal 2: Support one of the following alternatives to decrease UE-specific TA reporting overhead* Alt 1. Reporting of information to extrapolate/interpolate UE-specific TA

E.g. series of values with differential encoding scheme* Alt 2. Reporting of UE location (based on GNSS)
 |
| ZTE | ***Proposal-9:*** *The network request based TA reporting should be supported.* |
| Apple | ***Proposal 6:*** *Support at least event triggered TA reporting.*  |

## Means of reporting

### Companies’ Observations and Proposals

|  |  |
| --- | --- |
| Huawei | ***Proposal 6:*** *UE request TA reporting resources based on its speed to help eNB configure semi-static resource for differential TA reporting* |
| MediaTek Inc. | ***Proposal 2****: For initial access, the UE-specific full TA is reported by MAC CE.****Revised Proposal 3:*** *The UE-specific TA is reported by UE on MAC CE with following options for further discussions:** *UE-specific full TA*
* *UE-specific differential TA determined as the difference between the cell-specific TA and the UE-specific TA*
 |
| CATT | **Proposal 7: Using RRC signaling or MAC signaling to report TA can be supported.** |
| Qualcomm | ***Proposal 2*: The UE-specific TA is reported in an uplink semi-persistent scheduling (UL-SPS) message, such as the one used for reporting buffer status reports (BSRs) in NB-IoT.** |
| Sony | **Proposal 7: A timing advance command is associated with a reference time. The reference time indicates the time at which the timing advance is valid. The reference time of the timing advance command can be implicit or explicit and signaled to the UE either in MAC CE or PDCCH.** |
| Lenovo, Motorola Mobility | ***Proposal 2: UE report the TA value in msg3 and report the TA value in the following NPUSCH, the TA can be propagation delay***/***UE-specific TA (reflecting all or partial of round-trip delay) (e.g., one way delay, excluding the feeder link delay).******Proposal 3: Differential TA value can be reported in msg3 or NPUSCH and the differential TA can be the relative value to 1) broadcast common TA; 2) configured cell specific Koffset; 3) (previous) reported TA.*** |
| Nordic Semiconductor ASA | ***Proposal-3:*** *UE reports its UE-specific TA at least in MSG3 and eNB configures UE-specific* $K\_{offset,UE}$ *that is larger than total TA at least in MSG4.* |

# WUS

### Companies’ Observations and Proposals

|  |  |
| --- | --- |
| FGI, Asia Pacific Telecom, III, ITRI | Observation 1: RAN1 shall ensure whether Group WUS and WUS can be supportedProposal 7: An NB-IoT over NTN UE using NWUS shall assume there are at least X NB-IoT DL subframes between the end of the maximum duration of NWUS and the first associated NB-IoT paging occasion subframe. FFS: the value of X. |

## UL-DL Collision Handling for HD UE

It was agreed that reporting UE-specific TA can avoid UL-DL collision in FDD-HD UE in IoT-NTN. Meanwhile, the UL-DL collision issue may arise when two HARQ-Processes is configured, according to existing specification in TS 36.213/16.6, it should be considered to adapt impact of introduction of K\_offset due to large TA effect. For instance, assume NPUSCH transmission of 1st HARQ process start from subframe n+k+K\_offset, for single TB unicast case, a UE can continue receiving 2nd DCI Format N0 before subframe n+k-2+K\_offset, and the scheduled NPUSCH of second HARQ process will not exceed UL subframe n+k+255+K\_offset. Then with the retained constraint in current specification, the collision between the UL transmission and potential 2nd PDCCH reception can be avoided

### Companies’ views and proposals

|  |  |
| --- | --- |
| ZTE | ***Proposal-10:*** *For two HARQ-Processes, introduce K\_offset to maintain the timing between the UL transmission of 1st HARQ process and potential PDCCH reception of 2nd HARQ process.* |
| Nordic Semiconductor ASA | ***Proposal-1****: For eMTC and NB-IoT NTN, when switching from DL to UL, a guard period starts at subframe n +* $K\_{offset}$ *–* 1 *–* $TA\_{ceil}$*, where n is a subframe where UL transmission starts as per current specification, and* $TA\_{ceil}$ *is timing advance rounded up to number of subframes. When switching from UL to DL, a guard period ends at subframe n +* $K\_{offset}$ *+ N +* 1 *–* $TA\_{floor}$*, where N is the length of the UL transmission, and* $TA\_{floor}$ *is timing advance rounded down to number of subframes.* |

## RRC Parameters

Our views are provided in this section regarding the list of RRC parameters on timing relationship enhancement for IoT-NTN [8]. Given the current progress, all parameters listed in the Table 1, should be removed from the list. More specifically, similar as NR-NTN, only the MAC CE updates on the K\_offset may be needed, and no additional RRC parameter is needed.

For the TA report related parameter, there is no agreement to justify the new RRC parameter and based on the proposal in Section 3, the solution can be done without any RRC impacts once the granularity for report is fixed.

### Companies’ views and proposals

|  |  |
| --- | --- |
| ZTE | ***Proposal-12:*** *The updates on the RRC parameters listed in Table-1 should be supported.*  |
| GateHouse | Unclear what table 1 is referring to. |
|  |  |
|  |  |

# Appendix A

Note that in the SI phase, we made the following conclusion:

Conclusion:

The description of timing relationships for eMTC and NB-IoT in Rel-16 do not take the TA into account in general.

* Note: Exceptions to this may be identified as work on eMTC and NB-IoT over NTN progresses further.

Therefore, the specification already works for the case where DL & UL timing are aligned at the eNB, as illustrated by the figure below. (Note that similar spec text exists in RAN2 MAC spec.) In other words, the UE-eNB RTT has been implicitly incorporated already.



Here are a few clarifications:

1. In NR, the RA window is described in a different way. It does not use explicit numbering such as subframe n and subframe n + 4, as in the current spec. That’s the background of the following NR-NTN agreement:

Agreement:

The starts of ra-ResponseWindow and msgB-ResponseWindow are delayed by an estimate of UE-gNB RTT.

* The estimate of UE-gNB RTT is equal to the sum of UE’s TA and K\_mac.

Note 1: The UE’s TA is based on the RAN1#104bis-e agreement on Timing Advance applied by an NR NTN UE given by $T\_{TA}=\left(N\_{TA}+N\_{TA, UE-specific}+N\_{TA,common}+N\_{TA,offset}\right)×T\_{c}$. The estimate of gNB-satellite RTT is equal to the sum of $N\_{TA,common}×T\_{c}$ and K\_mac. How to treat $N\_{TA}$ and $N\_{TA,offset}$ can be further discussed.

Note 2: According to the RAN1#104bis-e agreement: When UE is not provided by network with a K\_mac value, UE assumes K\_mac = 0.

Note 3: The accuracy of the estimated UE-gNB RTT with respect to the true UE-gNB RTT can be further discussed.

Note 4: Other options of determining the estimate of UE-gNB RTT can be further discussed.

1. In PUR of IoT NTN, we have explicit numbering with subframe n and subframe n + 4, which makes the text work for the case where DL & UL frame timing are aligned at BS.
2. In fact, there is a similar case under discussion in NR NTN related to beam failure recovery procedure, which is sort of a RA procedure and has explicit numbering of slot n and slot n + 4. For that, the change needed is to revise the slot n + 4 to slot n + 4 + K\_mac.
3. So on how to address the case where DL & UL frame timing are NOT aligned at BS. The short answer is to revise the slot n + 4 to slot n + 4 + K\_mac, as illustrated in the figure below.



# Referenced Documents

[R1-2108751](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2108751.zip) Discussion on timing relationship enhancement for IoT in NTN Huawei, HiSilicon

[R1-2108932](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2108932.zip) Discussion on timing relationship enhancements for IOT NTN Spreadtrum Communications

[R1-2109012](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109012.zip) Discussion on timing relationship enhancements for NB-IoT/eMTC over NTN vivo

[R1-2109081](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109081.zip) Discussion on timing relationship enhancements OPPO

[R1-2109116](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109116.zip) Timing relationship enhancements Mavenir

[R1-2109172](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109172.zip) Timing relationship enhancements for IoT NTN MediaTek Inc.

[R1-2109177](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109177.zip) Timing relationship enhancements Qualcomm Incorporated

[R1-2109202](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109202.zip) Timing relationship enhancement for IoT over NTN CATT

[R1-2109266](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109266.zip) Timing relationship enhancements for NB-IoT/eMTC over NTN Nokia, Nokia Shanghai Bell

[R1-2109309](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109309.zip) Discussion on timing relationship enhancements for IoT NTN CMCC

[R1-2109322](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109322.zip) Timing Relationship for IoT NTN Lenovo, Motorola Mobility

[R1-2109397](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109397.zip) Discussion on the timing relationship enhancement for IoT NTN Xiaomi

[R1-2109523](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109523.zip) Timing relationship enhancements Samsung

[R1-2109641](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109641.zip) On timing relationship for NB-IoT and eMTC NTN Intel Corporation

[R1-2109805](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109805.zip) Timing relationships enhancement for IoT- NTN Sony

[R1-2109830](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109830.zip) Timing relationship enhancements to NB-IoT NTN FGI, Asia Pacific Telecom, III, ITRI

[R1-2109848](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109848.zip) Discussion on timing relationship for IoT-NTN ZTE

[R1-2109957](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2109957.zip) On timing relationship enhancements for IoT NTN Ericsson

[R1-2110064](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2110064.zip) Discussion on Timing Relationship Enhancements in IoT NTN Apple

[R1-2110262](file:///C%3A%5CUsers%5Cgbatungs%5CDocuments%5Csam%5Cstds%5C3GPP%5CRAN%5CRAN1%5CDocs%5CR1-2110262.zip) Timing relationship enhancements Nordic Semiconductor ASA