3GPP TSG-RAN WG1 Meeting #103-e R1-2009373

e-Meeting, October 26th – November 13th, 2020

Agenda Item: 8.4.1

Source: Moderator (Ericsson)

Title: Feature lead summary#1 on timing relationship enhancements

Document for: Discussion

# Introduction

A study item on solutions for NR to support non-terrestrial networks (NTN) was completed in Rel-16 [1]. The Rel-17 work item on solutions for NR to support NTN was approved at RAN#86 and the work item description is updated in [2]. One objective is to specify timing relationship enhancements for NTN.

In this contribution, we summarize the related issues and proposals based on the contributions submitted to RAN1#103-e under agenda item 8.4.1 [3] – [28].

# 1 Issue #1: Configuration of K\_offset

## 1.1 Background

At RAN1#102-e, configuration of Koffset was heavily discussed. The discussion status was summarized in Feature Lead summary [3] and a high-level agreement was made.

**RAN1#102-e:**

Agreement:

For K\_offset used in initial access, the information of K\_offset is carried in system information.

* FFS implicit and/or explicit signaling of K\_offset in system information.
* FFS a cell specific K\_offset value used in all beams of a cell and/or each beam in a cell uses a beam-specific K\_offset value.
* FFS whether/how to update K\_offset after initial access.

Based on the submitted contributions at RAN1#103-e, there are diverse proposals on how to configure Koffset.

## 1.2 Company views

### 1.2.1 Implicit and/or explicit signaling of K\_offset in system information

Many companies provide inputs on explicit and/or implicit signaling of Koffset, as summarized in the table below.

* It appears that the diverging situation does not change much compared to RAN1#102-e.
	+ More companies prefer explicit signaling of Koffset, but there are also quite some companies supporting implicit signaling of Koffset.
* The pros and cons of both directions have become clearer.

In Moderator’s view, based on the current status, it is unlikely that the situation would change much at RAN1#103-e. Further, the discussion on implicit signaling would depend on progress on other topics such as TA in A.I. 8.4.2. Thus, it appears sensible that we leave this discussion FFS until more design aspects of NTN become clearer.

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|  | Explicit signaling of Koffset | Implicit signaling of Koffset |
| Pros | * Flexible for gNB to configure
* Clean and more forward compatible
* Not coupled with other parameters, e.g. unified signaling framework to support both full TA and partial TA
 | * Save signaling by deriving from e.g.
	+ Common TA
	+ Random access related parameters
 |
| Cons | * Potential signaling redundancy as dependency of different system parameters are not yet clear
 | * The parameter used to derive Koffset is mandatorily present
* Coupling of parameters
	+ E.g. for common TA, problematic when common TA < RTT
	+ E.g. if Koffset is beam specific, the parameter used to derive it needs to be beam specific as well
 |
| Support | [CAICT, Ericsson, MediaTek, Eutelsat, CMCC (if common TA is not present), Asia Pacific Telecom, OPPO, NTT DOCOMO, CATT, Lenovo, Motorola Mobility, Apple, InterDigital, LG, Spreadtrum, China Telecom, ETRI] | [ZTE, Fraunhofer IIS, Fraunhofer HHI, CMCC (if common TA is present), Huawei, HiSilicon, Intel, China Telecom, Sony] |

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 1.2-1 (Moderator):**

Implicit and/or explicit signaling of K\_offset in system information can be left as FFS until more design aspects of NTN become clearer.

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| Company | Comments |
| MediaTek | Agree with proposal. We have preference for explicit signaling, but this discussion on Explicit Vs implicit can be postponed. |
| Intel | Agree with the proposal. We expect that implicit signaling can be supported in case the round trip delay is indicated by another parameter, since round trip delay is parameter of the deployment. However, if there is no such parameter we are fine with explicit indication. |
| Panasonic | Agree.  |
| OPPO | OK |
| CATT | Agree this proposal. Technically we prefer the explicit signaling, not coupled with other parameters since it is only related to TA alignment of service link.  |
| Apple | We agree with the FL proposal to delay the discussion until more design aspects of NTN are clear. Among the two options, we prefer explicit signaling of Koffset, considering gNB flexible configuration and forward compatibility. |
| Ericsson | We support the proposal. |
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### 1.2.2 Cell specific and/or beam specific value of Koffset in initial access

Many companies provide inputs on cell specific and/or beam specific value of Koffset in initial access, as summarized in the table below.

* It appears that the diverging situation does not change much compared to RAN1#102-e.
	+ The supporting companies are relatively equally split between the two options, cell specific and beam specific value of Koffset.
	+ Several companies propose to support both options so that gNB could choose which option to use.
* The pros and cons of supporting either option or both have become clearer.
* Configuring a cell specific value of Koffset in system information is straightforward, while how to configure beam specific value of Koffset in system information would require more discussion.

In Moderator’s view, based on the current status, it appears difficult to reach a consensus to go for only one option. A potential common ground would be to support both options.

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|  | Cell specific | Beam specific | Both |
| Pros | * Less signaling overhead while providing enough granularity for initial access
* Simple and straightforward; less specification impact
 | * Finer granularity
 | * Flexible for gNB to control the performance
 |
| Cons | * Coarser granularity compared to beam specific
 | * Larger overhead: Based on current SI design principle, a list of $K\_{offset}$ values need to be repeated across beams
* A different design for SIB needed to avoid repeating the list of $K\_{offset}$ values across beams
 | * More spec impact
 |
| Support | [Ericsson, Fraunhofer IIS, Fraunhofer HHI, Huawei, HiSilicon, Nokia, Nokia Shanghai Bell, Panasonic, NTT DOCOMO, CATT, Apple] | [ZTE, MediaTek, Eutelsat, CMCC, Lenovo, Motorola Mobility, InterDigital, Intel, Xiaomi, LG, Spreadtrum, ETRI] | [CAICT, OPPO, VIVO, Samsung] |

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 1.2-2 (Moderator):**

For K\_offset configured in system information and used in initial access, the following two options are supported:

* Option 1: configure a cell specific K\_offset value, which is used in all beams of a cell.
* Option 2: configure beam-specific K\_offset value(s), each of which is used by one beam in a cell.

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| Company | Comments |
| MediaTek | Agree with proposal. Both options could be supported from device viewpoint. Option 1 is straightforward and has less signaling overhead. For initial cell access, Koffset should be based then on maximum cell RTD. In case of large cell with many beams, this maximum RTD could be very large and much larger than would be needed to ensure proper UL scheduling operations of Msg3. Option 2 would allow Koffset to be based on a smaller RTD. |
| Intel | Support the proposal. In our view it is beneficial to have an option to indicate beam-specific K\_offset, especially for the case with very large cell coverage (e.g. GEO). |
| Panasonic | Support Option 1. Beam-specific Koffset can reduce the delay in operation with multiple beam per cell compared to cell-specific Koffset. But, considering Koffset value is UE specifically updated after initial access as discussed in section 1.2.3 below, the delay reduction effect of beam-specific K\_offset is only limited to during initial access.  |
| OPPO | Is the intention of the proposal to narrow down to one option or to agree supporting both options? |
| CATT | Agree, but we expect to have a complete comparison to make the progress. For K-offset configuration, if one beam/one initial BWP is linked to one cell for the initial access stage, then the motivation of configuring the K\_offset with beam specific way will disappear. This issue is coupled with beam management, so we prefer simple design, not violating R15 framework.  |
| Apple | It is unclear whether or not the two options will be further down selected.We support Option 1. A single cell specific Koffset reduces the signaling overhead. Though it is not optimized, a single cell specific Koffset used in the initial access is an acceptable solution.  |
| Ericsson | Our first preference is Option 1 only, but we could accept this compromise for progress. |
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### 1.2.3 Whether to update K\_offset after initial access

Many companies provide inputs on updating K\_offset after initial access. Most of the companies support updating K\_offset after initial access, while some companies propose restrictions.

* Companies supporting updating K\_offset after initial access include [CAICT, Ericsson, Fraunhofer IIS, Fraunhofer HHI, CMCC, Huawei, HiSilicon, Nokia, Nokia Shanghai Bell, Panasonic, OPPO, NTT DOCOMO, Apple, InterDigital, Qualcomm, Xiaomi, LG, Spreadtrum, ETRI]
	+ [Huawei, HiSilicon] hold the view that it is sufficient to update K\_offset to be beam-specific after initial access.
* [VIVO] hold the view that there is no need to update K\_offset if beam specific K\_offset is used in initial access.
* [CATT] hold the view that K\_offset update should be disabled for LEO.

In Moderator’s view, based on the current status, it is reasonable to support updating K\_offset after initial access and make it configurable.

* To address [CATT]’s view about disabling the update for LEO, it is sensible to make the option of updating K\_offset after initial access configurable by the network. Then for network that does not want to update K\_offset after initial access, the network does not configure it.
* To address [Huawei, HiSilicon] and [VIVO]’s view about using beam specific K\_offset after initial access:
	+ According to TR 38.821, the maximum satellite beam size (edge-to-edge) can be up to 3500 km for GEO or 1000 km for LEO, resulting in maximum differential delay of up to 10.3 ms for GEO or 3.2 ms for LEO within a satellite beam. Therefore, the maximum satellite beam size is also the maximum cell size, regardless of whether a cell consists of a single beam or multiple beams. Thus, using only beam-specific K\_offset after initial access does not resolve the issue.
	+ Anyhow, how to update K\_offset after initial access can be under network control. For network that does not want to use UE-specific K\_offset but beam-specific K\_offset after initial access:
		- If cell specific K\_offset is used for initial access, the network can configure the same K\_offset for all users in the same beam after initial access.
		- If beam specific K\_offset is used for initial access, the network can continue to use beam specific K\_offset for all users in the same beam after initial access.

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 1.2-3 (Moderator):**

K\_offset update after initial access is configurable by gNB.

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| Company | Comments |
| MediaTek | Agree with proposal. Assuming both option 1 and 2 in proposal 1.2-3, it seems reasonable that before initial cell access cell-specific Koffset is configured, then after initial cell access beam-specific is configured depending on cell size and number of beams.  |
| Intel | We are fine with the proposal as soon as reporting of TA applied by the UE is supported. Thus, K\_offset may be determined at the gNB based on the TA value. If such reporting is not supported – UE-specific K\_offset is not needed since it is not clear how to determine it.  |
| Panasonic | Support proposal 1.2-3.  |
| OPPO | support |
| CATT | For us, this proposal is unclear, not sure if it is UE specific updating or cell specific updating. Concrete design will impact the complexity of configuration and management. |
| Apple | Overall, we agree the specification should support the mechanism of updating Koffset after initial access. Also, we do not think “configurable by gNB” is necessary in the proposal. gNB can optionally signal UE about the Koffset update, like in FL proposal 1.2-4. Maybe, we could simply propose:“RAN1 supports Koffset update after initial access.” |
| Ericsson | We support this proposal. |
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### 1.2.4 How to update K\_offset after initial access

Based on the submitted contributions at RAN1#103-e, there are diverse proposals on how to update K\_offset after initial access, as summarized below.

* Option 1: RRC configuration
* Option 2: MAC CE
* Option 3: Group common DCI
* Option 4: Signaling multiple K\_offset values in a non-UE specific way which are used to update the UE applied value over time
* Option 5: UE updates the value of K\_offset based on predefined rules

There are also several companies proposing that UE reports TA, which can facilitate network updating K\_offset after initial access. Besides, UE reporting TA may serve other purposes as well. But its discussion would depend on progress on other topics such as TA in A.I. 8.4.2. Thus, the following moderator recommendation from RAN1#102-e still holds.

 ***[RAN1#102-e] Moderator recommendation on Issue #5:***

* *Handle TA focused proposals under A.I. 8.4.2, or treat them under A.I. 8.4.1 once sufficient progress has been made in A.I. 8.4.2.*

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 1.2-4 (Moderator):**

Discuss how to update K\_offset after initial access:

* Option 1: RRC configuration
* Option 2: MAC CE
* Option 3: Group common DCI
* Option 4: Signaling multiple K\_offset values in a non-UE specific way which are used to update the UE applied value over time
* Option 5: UE updates the value of K\_offset based on predefined rules

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| Company | Comments |
| MediaTek | We think discussions on the options to update Koffset after initial access could be postponed. We agree that UE autonomous TA report to gNB can wait until progress is made in AI 8.4.2. We also think it is needed to further discuss the trigger mechanisms to update Koffset and what the value of Koffset should be after initial cell access. Proposals 1.2-2 and 1.2-3 could be sufficient at least for FDD. For HD-FDD, further discussion seem needed to avoid UL-DL subframe collision issue.  |
| Intel | If UE-specific K\_offset is supported, we prefer RRC configuration or MAC CE signaling as it is more reliable. |
| Panasonic | We support option 1 for GEO and option 2 or option 3 for LEO. For GEO, Koffset would be update once after initial access via RRC configuration because satellite position is static. On the other hand, for LEO, in order to minimize the delay, Koffset should be frequently updated according to satellite movement in case of LEO. Relative value indication to the current value via MAC CE or Group common DCI would be desired.  |
| OPPO | At least option1 should be supported so that the K offset can be UE-specifically configured. Option 2 and Option 3 are to be further considered.  |
| CATT | In this stage, it is too early to make the agreement on detail design of K\_offset updating. Whether to need the updating and how to trigger the updating are unclear totally. For example, if no TA reporting, how to update the K-offset? |
| Apple | Overall, we support the proposal. In Option 4, it is unclear in which signal to “signaling multiple Koffset values”.  |
| Ericsson | RRC configuration is the basic mechanism for reconfiguring parameters. Thus, at least Option 1 should be supported. |
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## 1.3 Updated proposal based on company views (1st round of email discussion)

To be added…

# 2 Issue #2: MAC CE command timing relationship

## 2.1 Background

At RAN1#102-e, MAC CE command timing relationship was heavily discussed. The discussion status was summarized in Feature Lead summary [3] and the following Moderator recommendation was made.

**RAN1#102-e:**

**Moderator recommendation on Issue #3:**

On MAC CE timing relationship, companies are encouraged to conduct more investigations and provide input to RAN1#103-e.

When conducting the analysis, companies may consider the following understanding as a starting point:

* *[UL MAC CE] For a MAC CE command received in DL slot n, where the command is used to indicate to the UE about an action in the UL or an assumption on the uplink configuration, the UE assumes the command is activated in the* ***UL slot*** *(at UE side)* $n+k\_{1}+3N\_{slot}^{subframe,µ}+1$*, where TA is assumed to be zero and the UL slot indexed by* $n+k\_{1}$ *is the UL slot where UE transmits HARQ-ACK corresponding to the received PDSCH carrying the MAC CE command.*
* *[DL MAC CE] For a MAC CE command received in DL slot n, where the command is used to indicate to the UE about an action in the DL or an assumption on the downlink configuration, the UE assumes the command is activated in the* ***DL slot*** *(at UE side) which is the first DL slot after the UL slot* $n+k\_{1}+3N\_{slot}^{subframe,µ}$*, where TA is assumed to be zero and the UL slot indexed by* $n+k\_{1}$ *is the UL slot where UE transmits HARQ-ACK corresponding to the received PDSCH carrying the MAC CE command.*

Companies are encouraged to analyze the above further with a focus on the following aspects:

* Whether the principle described above applies to all MAC CE’s in existing NR.
* When TA becomes large in NTN, and DL timing and UL timing are aligned at gNB:
	+ How to modify the timing relationship?
	+ Does the modification need to be different depending on the type of MAC CE?
* When DL timing and UL timing are not aligned at gNB.

Many companies provide inputs on MAC timing relationship for RAN1#103-e, several of which provide good analysis.

* [CAICT, Ericsson, ZTE, MediaTek, Eutelsat, CMCC, Asia Pacific Telecom, Nokia, Nokia Shanghai Bell, Panasonic, OPPO, CATT, vivo, Lenovo, Motorola Mobility, Apple, InterDigital, Samsung, Qualcomm, Intel, Xiaomi, LG]

Based on the submitted contributions, it is clear that the issue is complicated and requires step-by-step discussion, which is especially needed during the current e-meeting way of discussion in RAN1.

[Asia Pacific Telecom] provides good categorization of MAC CE timing in existing spec:

**[Asia Pacific Telecom] - Action time on Rel-16 spec:**

Note that there exist four different wordings (and three different timing) in Rel-16 for the action time

1. given a specific slot number with no TA, e.g., slot $p=n+k'+1$; or
2. timing after a given slot, e.g., the first slot that is after slot $q=n+k'$; or
3. given a specific UL slot number, e.g., UL slot $r=m+k+1$; or
4. given a specific processing time in absolute time, e.g., $s=m+4ms$ (after 4ms),

where $n$ refers to a slot for HARQ-ACK, $m$ refers to a slot for a timing advance command reception, and k and k’ are related to UE processing time.



Figure 1: MAC CE activation timing in Rel-16

Figure 1 shows different MAC CE action time supported in Rel-16, where

* action #1: MAC CE action time for SCell, PUCCH spatial relation, SP CSI reporting, and SP SRS
* action #2: MAC CE action time for SP ZP CSI-RS, TCI States, Aperiodic CSI, SP CSI-RS/CSI-IM
* action #3: MAC CE action time for Timing Advance Command
* action #4: MAC CE action time for DRX Command

Based on our understanding, the UE DL slot p shall not be a correct MAC CE action time, wrong interpretation to us.

[Asia Pacific Telecom] further reviews interpretation of MAC CE timing in existing spec:

**[Asia Pacific Telecom] - Action time interpretation:**

Rel-16 spec text is not crystal clear about the MAC CE action timing. The ambiguity comes from whether UE shall determine the action time before or after timing advance is applied. To handle this, the terms *Logical Time* and *Actual Time* are introduced based on RAN1#98-Bis consensus, where

* *Logical Time* means that all the following is assumed to be zero
	+ DL-to-DL timing differences between CCs
	+ UL-to-UL timing differences across different TAGs
	+ UL timing advance
* *Actual Time* means that values observed by the UE are assumed for
	+ DL-to-DL timing differences between CCs
	+ UL-to-UL timing differences across different TAGs
	+ UL timing advance

In the consensus, MAC CE action time was categorized into *Logical Time*. That means UE shall make a logical MAC CE action in a slot number based on the spec text and then actually apply the MAC CE after UL timing advance.



**Figure 2: Consensus made after RAN1#98-Bis for MAC action time**

In short:

* There are various types of MAC CEs in NR, which can be found in TS 38.821. Some of these MAC CEs (e.g. the Recommended Bit Rate MAC CE) do not involve timing relationships defined in the physical layer specifications. Clearly, RAN1 discussion on MAC CE timing relationships is only relevant for those MAC CEs that involve timing relationships defined in the physical layer specifications.
* In general, for MAC CE timing relationships defined in the physical layer specification, the MAC CE command becomes activated 3 ms after UE transmits HARQ-ACK corresponding to the received PDSCH carrying the MAC CE command. However, there are exception(s). For example, the adjustment of the uplink transmission timing corresponding to a timing advance command MAC CE is one such exception:

Section 4.2, TS 38.213:

For a timing advance command received on uplink slot  and for a transmission other than a PUSCH scheduled by a RAR UL grant as described in Subclause 8.3, the corresponding adjustment of the uplink transmission timing applies from the beginning of uplink slot  where ,…

To facilitate RAN1 discussion, we could proceed as follows:

* General MAC CE timing relationship discussions are assumed to be applicable to those MAC CEs that involve “3 ms application delay” defined in the physical layer specifications.
* Exceptional MAC CE timing relationships where the general discussion is not applicable may be discussed case by case based on company input.

The first part of the below table attempts to categorize companies’ views along this line of thinking. The second part of the below table collects general companies’ views.

|  |  |  |  |
| --- | --- | --- | --- |
|  | General MAC CE with aligned UL-DL frame timing | General MAC CE with unaligned UL-DL frame timing | Exceptional MAC CE timing |
| Ericsson | Koffset is not needed for DL MAC CEKoffset is not needed for UL MAC CE | Offset is needed for DL MAC CE (but not called Koffset)Koffset is not needed for UL MAC CE | MAC CE action time for Timing Advance Command |
| ZTE | Koffset is not needed for DL MAC CEKoffset is not needed for UL MAC CE |  | MAC CE action time for Timing Advance Command |
| Asia Pacific Telecom | Koffset is not needed for DL MAC CEKoffset is not needed for UL MAC CE |  | * MAC CE action time for Timing Advance Command
* MAC CE action time for DRX Command
 |
| Intel | Koffset is not needed for DL MAC CE | Offset is needed for DL MAC CE (but not called Koffset) |  |
| VIVO | Koffset is not needed for DL MAC CE (?)Koffset is not needed for UL MAC CE (?)(this is moderator’s understanding of the figures, but the formulated proposal indicated the converse) | Offset is needed for DL MAC CE (but not called Koffset) (?)Koffset is not needed for UL MAC CE (?)(this is moderator’s understanding of the figures, but the formulated proposal indicated the converse) |  |
|  | General views |
| CAICT | Koffset is needed for DL MAC CE. Its necessity for UL MAC CE depends on whether or not the command is dependent on DL scheduling. |
| Lenovo, Motorola Mobility | MAC CE activation delay is determined by the gNB UL-DL timing shift |
| Meditatek, Eutelsat | Koffset is needed for MAC CE |
| CMCC | Discussion should be based on the assumption for aligned DL-UL timing at gNB side |
| Nokia, Nokia Shanghai Bell | Discuss the understanding of MAC-CE action timing for both the long TA and short TA |
| PANASONIC | * Koffset not needed for UL MAC CE
* DL status should be defined based on an offset from the reception timing of PDSCH containing the MAC CE
 |
| OPPO | Koffset is needed to absorb further the propagation delay |
| CATT | RTD needs to be considered in MAC CE |
| Apple | Koffset is not needed for UL MAC CE, but is needed for DL MAC CE |
| Interdigital | Support Koffset for MAC-CE action timing |
| Samsung | * The range of Koffset should depend on the maximum round trip propagation delay Trt and the maximum hop number L as Koffset ≥ L×Trt
* Koffset is applied to the determination of MAC CE activation timing
 |
| Qualcomm | Introduce Koffset for MAC CE |
| Xiaomi | Different Koffset value is applied to the activation of MAC CE. |
| LG | At least for MAC-CE associated with DL transmission, K\_offset is needed. |

## 2.2 Company views

To start the discussion, it is recommended to focus on the simpler case, where downlink and uplink frame timing are aligned at gNB. When consensus is achieved for this case, we could move on to discuss the more complicated case, where downlink and uplink frame timing are not aligned at gNB.

Understanding of existing MAC CE timing relationships was heavily discussed in Rel-15 maintenance. Common understanding, based on the conclusion at RAN1#98bis, can be found in R1-1911583. Note that Koffset for MAC CE in Rel-16 NTN SI was identified at RAN1#98bis as well, so the thinking at that time for Koffset would need to be updated based on the common understanding of the specification.

In short, the discussion in R1-1911583 indicates that UE assumes MAC CE command is active 3 ms after it transmits HARQ ACK corresponding to a received PDSCH carrying the MAC CE command.

The figure below illustrates if TA = 0, gNB and UE would have the same understanding that MAC CE command is activated in slot m.



The figure below illustrates if TA > 0 but not too large, gNB and UE would have the same understanding that MAC CE command is activated in slot m.



The main difference between NTN and terrestrial networks is that large TA value may need to be applied in NTN. Let’s start the analysis with the assumption that downlink and uplink frame timing are aligned at gNB.

The figure below illustrates the case in question. In this figure, UE applies a large TA. Due to this, gNB uses Koffset and k1 together to indicate the slot where the UE is scheduled to transmit HARQ-ACK. As shown in this figure, with the existing MAC CE timing relationship, gNB and UE would have the same understanding that MAC CE command is activated in slot m. So, there is no need to introduce additional Koffset for MAC CE timing relationship in this case.



Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 2.2-1 (Moderator):**

* RAN1 to conclude that when downlink and uplink frame timing are aligned at gNB:
	+ For DL MAC CE timing relationship, K\_offset is not needed
	+ For UL MAC CE timing relationship, K\_offset is not needed
* FFS when downlink and uplink frame timing are not aligned at gNB.
* Note: This does not preclude identifying exceptional MAC CE timing relationship(s) that may or may not require K\_offset.

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| Company | Comments |
| MediaTek | There could be error case where the UL HARQ feedback on a DL MAC CE is not received at the gNB. It is not clear what happens with UE for example receiving TCI state indication for UE-specific MAC CE but gNB assumes UE has not done switching TCI because it did not receive UL HARQ feedback. Because of satellite RTD, it could take a long time for UE and gNB to realise something went wrong – i.e. at least satellite RTD. The error case could be avoided if Koffset is included in time when UE assumes MAC CE is activated.  |
| Intel | Support the proposal 2.2-1 |
| Panasonic | Support proposal 2.2-1 when DL and UL timing are aligned at gNB. On the other hand, in terrestrial operation, UE doesn't know whether DL and UL timing are aligned at gNB. In case of LEO, our view is that DL and UL timing would not be aligned at gNB because of the feeder link delay varying according to the satellite movement. Therefore, an offset is needed for DL MAC CE reflection timing.  |
| OPPO | Agree with the proposal and regarding MTK’s comment, how adding K offset would resolve the issue of miss-detecting UL HARQ-ACK? |
| CATT | In principle, we are ok for this proposal. But since transparent payload is the main assumption for this WI, the case that downlink and uplink frame timing are not aligned at gNB should be prioritized, because feeder link delay can be compensated by the gNB. |
| Apple | For UL MAC CE timing relationship, we think that Koffset is not needed, no matter whether DL and UL frame timing is aligned at gNB. For DL MAC CE timing relationship, we think Koffset is needed for DL MAC CE timing relationship when gNB has unaligned DL and UL frame timing. Similar to CATT, we think the case that DL and UL frame timing unaligned at gNB should be prioritized.  |
| Ericsson | We support the proposal. |
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## 2.3 Updated proposal based on company views (1st round of email discussion)

To be added…

# 3 Issue #3: On K1/K2 range extension

## 3.1 Background

At RAN1#102-e, K1/K2 range extension was discussed. The discussion status was summarized in Feature Lead summary [3]. After 2 rounds of email discussions at RAN1#102-e, it became clear that it is better to separate the discussion of updating Koffset from the discussion of extending value ranges of K1 and/or K2, as preferred by many companies.

At RAN1#103-e, several companies provide proposals on this topic. It appears that the input to this topic is not many. That said, it is unclear if companies change their mind after reading the newly submitted contributions at RAN1#103-e. So, in Moderator’s view, it may be beneficial to collect companies’ views again and check the necessity of K1/K2 range extension for NTN.

**[CAICT]:**

Proposal 6: To enhance K1/K2 indication with explicit or implicit way in TDD system which is with more contiguous DL slots.

**[Lenovo, Motorola Mobility]:**

Proposal 5: Support extending the range of K1 value.

**[ZTE]:**

Proposal 4: Extension of existing offset (i.e., k, K1, K2) should be supported.

**[MTK, Eutelsat]:**

Proposal 4: K1 range are increased to 32 with indication of INTEGER (0..31) in dl-DataToUL-ACK field in PUCCH-Config.

Proposal 5: K2 range are increased to 64 with indication of INTEGER (0..63) in PUSCH-TimeDomainResourceAllocation field in DCI .

**[CMCC]:**

Proposal 8: Extend the value range of K1 to larger than 15, e.g., 31.

**[CATT]:**

Proposal 5: Expanding K1/K2 is not necessary.

## 3.2 Company views

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 3.2-1 (Moderator):**

Discuss whether to extend value ranges of K1 and/or K2.

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| Company | Comments |
| MediaTek | At least K1 could be increased following RAN1 agreement on supporting 32 HARQ processes. |
| Intel | It is not clear if it is needed since K\_offset is added to both K1 and K2. Moreover, if UE-specific K\_offset is supported it will have similar functionality as K1 and K2 except that it is same for HARQ and PUSCH transmissions. |
| Panasonic | We don’t see the need of extending K1 and/or K2 values so far.  |
| OPPO | Could we discuss if the extension would change the DCI size or not? |
| Apple | We may hold this discussion after the discussion of Koffset in or after initial access. Depending on the accuracy of Koffset, we may then know whether the ranges of K1 and K2 need to be extended.  |
| Ericsson | We are fine to discuss. |
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## 3.3 Updated proposal based on company views (1st round of email discussion)

To be added…

# 4 Issue #4: Configured grant timing relationships

## 4.1 Background

At RAN1#103-e, a few companies provide proposals on this topic:

**[Apple]:**

Proposal 6: Introduce $K\_{offset}$ to the timing relationship for type 1 configured grant.

**[Samsung]:**

Proposal 4:The timing relationship for Configured Grant Type 1 should be left to Network implementation.

Proposal 5: The timing relationship for Configured Grant Type 2 can follow the timing relationship for DCI scheduled PUSCH.

At RAN1#102-e, configured grant timing relationship was discussed. The discussion status was summarized in Feature Lead summary [3]. Based on the submitted contributions at RAN1#103-e, it appears that the input to this topic is limited. That said, it is unclear if companies change their mind after reading the newly submitted contributions at RAN1#103-e. So, in Moderator’s view, it may be beneficial to collect companies’ views again and check the necessity of enhancing configured grant timing relationships for NTN.

## 4.2 Company views

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 4.2-1 (Moderator):**

Discuss which direction to take for the timing relationship of type 1 configured grant:

* *Option 1: [Apple] Introduce K\_offset to the timing relationship for type 1 configured grant.*
* *Option 2: [Samsung] The timing relationship for Configured Grant Type 1 should be left to Network implementation.*

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| Company | Comments |
| Panasonic | Support Option 2. |
| Apple | We support Option 1. Configured grant type 1 involves the DL-UL timing interaction, and hence, it is natural to introduce Koffset to it, just like the other timing relationship enhancement cases. If we leave the timing relationship for configured grant type 1 to network implementation, then the network may have to modify configured grant type 1 based on a new Koffset at every Koffset update. This is not preferred.  |
| Ericsson | We feel Option 2 is sufficient.  |
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**Initial proposal 4.2-2 (Moderator):**

Discuss the following proposal for the timing relationship of type 2 configured grant:

*[Samsung] The timing relationship for Configured Grant Type 2 can follow the timing relationship for DCI scheduled PUSCH.*

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| Company | Comments |
| Panasonic | We agree that the timing relationship for Configured Grant Type 2 can follow the timing relationship for DCI scheduled PUSCH. |
| Ericsson | It should be clarified that the timing relationship here for CG type 2 refers to the activation timing.  |
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## 4.3 Updated proposal based on company views (1st round of email discussion)

To be added…

# 5 Issue #5: 2-Step RACH timing relationships

## 5.1 Background

At RAN1#103-e, a few companies provide proposals on this topic:

**[Asia Pacific Telecom co. Ltd]:**

Proposal 5: Timing enhancement on 2-step RACH shall start in RAN1#103-e.

**[ZTE]:**

Proposal 7: For the 2-step RACH, introduce K\_offset for the transmission timing of fallback random-access response (RAR) scheduled PUSCH and HARQ-ACK feedback for Msg-B.

**[Fraunhofer IIS, Fraunhofer HHI]:**

Proposal 10: RAN1 to further study the enhancement of 2-step RACH timing relationship for NTN.

At RAN1#102-e, 2-Step RACH timing relationship was discussed. Based on the discussion as summarized in Feature Lead summary [3], Moderator recommended that RAN1 wait for RAN2 decision on whether to support 2-step RACH for NTN or not, before discussing 2-step RACH timing relationship.

RAN2 now has agreed to support both 2-step and 4-step RACH in Rel-17 NTN. So, it is reasonable to start discussing 2-step RACH timing relationship in RAN1.

*[RAN2#111-e agreement] Both 2-step and 4-step RACH are supported in Rel-17 NTN. FFS enhancements to RACH to accommodate the NTN environment.*

[Asia Pacific Telecom co. Ltd] provide good figures to illustrate timing relationships that should be discussed in RAN1.

**[Asia Pacific Telecom co. Ltd]:**

Figure 4 shows an example when UE receives a fallbackRAR within the MsgB-RAR window, where 1st offset and 3rd offset might be derived by UE, and 2nd offset and 4th could be provided by NW. In our example, C-RNTI is provided for PDCCH monitoring, the UE may transmit HARQ-ACK information for the received Msg4, meanwhile, NW shall guarantee proper scheduling regarding required TA and UE processing time.



Figure 4: Example of a fallbackRAR reception within the MsgB-RAR window

However, detail on 1st offset, 3rd offset, and 4th offset is unclear. More discussion shall be needed in RAN1.

Figure 5 shows another example when UE receives a successRAR within the MsgB-RAR window. Note the HARQ-ACK information shall be ACK value only. Timing enhancement on 2nd offset might need some discussion in RAN1.



Figure 5: Example of a successRAR reception within the MsgB-RAR window

Figure 6 shows another example when the MSGA includes the C-RNTI MAC CE. In this case, UE may receive a DCI format in the PDCCH within the MsgB-RAR window. The DCI format in PDCCH shall provide the 2nd offset for HARQ-ACK information, either ACK or NACK values, for the received PDSCH, and NW shall guarantee that the 2nd offset is long enough to cover the 2nd TA value required for the PUCCH transmission. Details shall be discussed further.



Figure 6: Example of C-RNTI MAC CE included in the MSGA transmission

In summary, as illustrated by the above figures from [Asia Pacific Telecom co. Ltd], there are 3 types of timing relationships.

* Transmission timing of fallback RAR scheduled PUSCH
* Reception timing of HARQ-ACK feedback for MsgB
* Offset to the start of MsgB-RAR window (similar discussion is applicable to the start of Msg2-RAR window) and offset to the start of ra-ContentionResolutionTimer window

## 5.2 Company views

### 5.2.1 FallbackRAR scheduled PUSCH

The FallbackRAR scheduled PUSCH is similar to the Msg2 RAR scheduled PUSCH. Given that RAN1 has agreed to introduce K\_offset in the transmission timing of Msg2 RAR grant scheduled PUSCH, it is natural to apply the same design to FallbackRAR scheduled PUSCH.

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 5.2-1 (Moderator):**

Introduce K\_offset to enhance the timing relationship of fallbackRAR scheduled PUSCH.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | Support the proposal 5.2-1 |
| Panasonic | Support proposal 5.2-1.  |
| OPPO | support |
| Apple | Agree |
| Ericsson | This is reasonable. |
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### 5.2.2 HARQ-ACK to MsgB

[Asia Pacific Telecom co. Ltd] describe two cases of HARQ feedback to MsgB (see Figures 5 and 6 in [Asia Pacific Telecom co. Ltd]’s contribution, which are also cited in Section 5.1 in the above).

In either case, the HARQ-ACK to MsgB is similar to the case of HARQ-ACK on PUCCH to a normal PDSCH. Given that RAN1 has agreed to introduce K\_offset in the transmission timing of HARQ-ACK on PUCCH, it is natural to apply the same design to HARQ-ACK to MsgB.

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 5.2-2 (Moderator):**

Introduce K\_offset to enhance the timing relationship of HARQ-ACK on PUCCH to MsgB.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | Support the proposal 5.2-2 |
| Panasonic | Support proposal5.2-2. |
| OPPO | support |
| Apple | Agree |
| Ericsson | This is reasonable. |
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### 5.2.3 Start of Msg2/MsgB RAR window

At RAN2#111, the following agreement was made about adding offset to the starts of ra-ResponseWindow and ra-ContentionResolutionTimer.

*[RAN2#111-e agreement]*

*1. From RAN2 perspective, an offset is applied to the start of ra-ResponseWindow in NTN for both LEO and GEO scenarios.*

*2. An offset to the start of the ra-ContentionResolutionTimer is introduced for both LEO and GEO scenarios.*

The start of ra-ResponseWindow is defined in RAN2 spec TS 38.321 and its discussion can be up to RAN2, and thus there is no highlight of “From RAN2 perspective” in the RAN2 agreement.

The first bullet in the RAN2 agreement however highlights that the offset to the start of ra-ResponseWindow can be added “from RAN2 perspective”, because the start of ra-ResponseWindow is specified in RAN1 spec TS 38.213 and thus RAN2 expects coordination with RAN1 is needed.

Section 8.2, TS 38.213 – 4-step RACH:

… The window starts at the first symbol of the earliest CORESET the UE is configured to receive PDCCH for Type1-PDCCH CSS set, as defined in Clause 10.1, that is at least one symbol, after the last symbol of the PRACH occasion corresponding to the PRACH transmission, where the symbol duration corresponds to the SCS for Type1-PDCCH CSS set as defined in Clause 10.1. …

Section 8.2A, TS 38.213 – 2-step RACH:

… The window starts at the first symbol of the earliest CORESET the UE is configured to receive PDCCH for Type1-PDCCH CSS set, as defined in Clause 10.1, that is at least one symbol, after the last symbol of the PUSCH occasion corresponding to the PRACH transmission, where the symbol duration corresponds to the SCS for Type1-PDCCH CSS set. …

During the Rel-15 maintenance at RAN1#98bis, many timing relationships were clarified with respect to whether TA is considered or not in the corresponding timing relationship (see R1-1911583). But whether TA is considered or not for defining the start of Msg2/MsgB RAR window was not discussed and appears to be not clear.

The following figure provides an illustration.



For PRACH transmission in the slot indicated in yellow:

* If TA is assumed to be zero, the RAR window should start at PDCCH monitoring occasion 2.
* When TA is not large as in terrestrial case (TA is small), it does not matter whether TA is assumed to be zero or not, the RAR window would start at PDCCH monitoring occasion 2.
* When TA is large as in NTN case, it matters whether TA is assumed to be zero or not
	+ If logical timing is used (TA is assumed to be 0), the RAR window starts at PDCCH monitoring occasion 2. In this case, UE implicitly adds an offset already to the start of the RAR window when it comes to the actual timing.
	+ If actual timing is used, the RAR window starts at PDCCH monitoring occasion 1 according to current spec text. In this case, UE would need to add an explicit offset (e.g. equal to RTT) to the start of the RAR window so that the UE starts the RAR window at PDCCH monitoring occasion 2 (instead of 1).

Therefore, it is necessary to first clarify the interpretation of the existing RAN1 specification about the start of the Msg2/MsgB RAR window, particularly whether or not TA is considered.

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 5.2-3 (Moderator):**

Discuss the interpretation of the existing TS 38.213 spec text on the start of Msg2/MsgB RAR window:

* Interpretation 1: Logical timing, i.e., TA is not considered and assumed to be zero
* Interpretation 2: Actual timing, i.e., TA is considered.

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| --- | --- |
| Company | Comments |
| Intel | The same solution as for 4-step RACH RAR window can be considered |
| Panasonic | Existing text seems not consider TA, but for NTN it should be explicitly described that TA is not considered and assumed to be zero.  |
| OPPO | Interpretation 2 |
| Ericsson | We are open to discuss how to interpret it for NTN. Interpretation 1 appears simpler for NTN.  |
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## 5.3 Updated proposal based on company views (1st round of email discussion)

To be added…

# 6 Issue #6: SFI timing relationship

## 6.1 Background

At RAN1#103-e, a few companies provide proposals on this topic:

**[CAICT]:**

Proposal 1: In NTN, SFI-index field value in a DCI format 2\_0 indicates slot format for a number of slots starting from the slot which is at least $K\_{offset}$ slots after the UE detects the DCI format 2\_0.

**[Lenovo, Motorola Mobility]:**

Proposal 2: DCI 2-0 application delay should be determined by twice the propagation delay between gNB and UE if uplink slot/symbol is indicated by DCI 2-0.

Proposal 3: Consider slot format ending with several F slot/symbols.

**[OPPO]:**

Proposal 6: K\_offset should be introduced for SFI interpretation for an uplink BWP.

**[MediaTek, Eutelsat]:**

Proposal 7: The SFI-index field value in a DCI format 2\_0 is delayed by Koffset corresponding to maximum RTD in the beam.

At RAN1#102-e, SFI timing relationship was discussed. The discussion status was summarized in Feature Lead summary [3] as follows. Based on the submitted contributions at RAN1#103-e, it appears that the interest in this topic is still not high. That said, it is unclear if companies change their mind after reading the newly submitted contributions at RAN1#103-e. So, in Moderator’s view, it may be beneficial to collect companies’ views again and check the necessity of introducing Koffset to enhance the DCI 2\_0 scheduled SFI timing relationship for NTN.

**Feature lead summary on SFI timing relationship from RAN1#102-e:**

In the second round of email discussion, 17 companies provided views regarding DCI 2\_0 scheduled SFI timing relationship. The majority, 13 companies (Intel, CATT, Panasonic, Huawei, APT, ZTE, Xiaomi, LG, Ericsson, Thales, Nokia, Fraunhofer IIS/ Fraunhofer HHI, Apple), do not see the need of using DCI 2\_0 for NTN or do not think it is urgent to resolve this at this RAN1 meeting (i.e., FFS).

Considering the views expressed by companies, we can see that there is no strong support for this issue. In contrast, many companies are questioning the necessity. A recommended way forward is provided as follows.

**Moderator recommendation on Issue #4 – DCI 2\_0 scheduled SFI:**

On DCI 2\_0 scheduled SFI timing relationship, interested companies are encouraged to justify the need and submit concrete proposals to RAN1#103-e.

## 6.2 Company views

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 6.2-1 (Moderator):**

Discuss the necessity of introducing K\_offset to enhance the DCI 2\_0 scheduled SFI timing relationship for NTN.

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| --- | --- |
| Company | Comments |
| MediaTek | DCI Format 2\_0 is used to provide the Slot Format Indicator (SFI) that defines a pointer towards a specific Slot Format Combination used for UE transmission pattern. The Slot Format Configuration starts at the UE side will be delayed by at least the satellite propagation delay. Each UE in a UE group may experience different RTDs over the access link. This may be issue for HD-FDD and can be avoided if Koffset based on maximum RTD is used. |
| Panasonic | The main use case of DCI 2\_0 is dynamic change of uplink and downlink in TDD. Such operation is not efficient for larger cell because of the possible collision between uplink and downlink from different cells suffers more. Therefore, our view is DCI 2\_0 is not required to be optimized in NTN. |
| OPPO | Maybe what we have to first agree on is whether we need to support the SFI function in NTN.  |
| Ericsson | We’re open to discuss, though we don’t think it’s essential to use DCI 2\_0 in NTN. |
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## 6.3 Updated proposal based on company views (1st round of email discussion)

To be added…

# 7 Issue #7: PDCCH ordered PRACH

## 7.1 Background

[CAICT] make the following observation on PDCCH ordered PRACH:



Fig. 2 The illustration of RO selection in the RACH procedure triggered by PDCCH order.

Observation 3: If a TA is pre-compensated to the PRACH transmission, current PRACH occasion determination manner in the RACH procedure triggered by PDCCH order will not work, since the timing-gap between the time of receiving PDCCH order and the time of selected RO might be smaller than the necessary pre-compensated TA.

Based on the observation, [CAICT] propose the following:



Fig. 3 The illustration of RO selection after a timing offset in the RACH procedure triggered by PDCCH order.

Proposal 2: When a RACH procedure is trigged by PDCCH order, UE shall select the next available RO after a timing offset according to the indication of PDCCH order, where the timing offset can use the $K\_{offset}$ explicitly indicated by gNB or implicitly related to the TA reported by UE.

In Moderator’s view, this appears to be a valid issue that requires discussion. Before discussing potential solutions, it should be first discussed whether the observation is correct to see if there is any issue with the timing of the PDCCH ordered PRACH.

## 7.2 Company views

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 7.2-1 (Moderator):**

Discuss whether the following observation on PDCCH ordered PRACH is correct or not:

*[CAICT] If a TA is pre-compensated to the PRACH transmission, current PRACH occasion determination manner in the RACH procedure triggered by PDCCH order will not work, since the timing-gap between the time of receiving PDCCH order and the time of selected RO might be smaller than the necessary pre-compensated TA*.

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| Company | Comments |
| Panasonic | UE would transmit PRACH in the next available RACH occasion after reception of PDCCH order. Because gNB would have a rough knowledge of RTT, gNB can detect the PRACH in the candidate ROs. Therefore, PDCCH order PRACH can work without Koffset. On the other hand, it might not be harmful to use Koffset to alleviate potential gNB complexity because Koffset is already available.  |
| OPPO | We have a different understanding. When a UE receives a PDCCH order, the indicated ROs are periodic, the spec does not seem to mandate the UE to select only one RO.  |
| Ericsson | This appears to be a valid issue that requires discussion. |
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## 7.3 Updated proposal based on company views (1st round of email discussion)

To be added…

# 8 Issue #8: RRC procedure delay

## 8.1 Background

[Oppo] propose to introduce Koffset to enhance the RRC procedure delay.

The motivation of introducing K\_offset for MAC-CE activation time is to increase the buffer time for the gNB to receive the HARQ-ACK information from the UE. A similar reason can be considered for the RRC procedure delay. In TN system, the RRC procedure delay is a fixed duration, e.g. for RRC reconfiguration the delay is 10 ms, which is long enough for HARQ-ACK feedback in TN network. But the configured delay value in current spec cannot cover the propagation delay in NTN system such as for GEO. For this reason, the RRC procedure delay should also be revisited, e.g., K\_offset should be introduced to the configuration of RRC procedure delay.

**Proposal 5: K\_offset should be introduced to enhance the RRC procedure delay.**

In Moderator’s view, RRC procedure delay, as defined in TS 38.331, is a RAN2 topic and should be discussed in RAN2.

## 8.2 Company views

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 8.2-1 (Moderator):**

It is recommended that the proponent bring up the following proposal in RAN2:

*[OPPO] K\_offset should be introduced to enhance the RRC procedure delay.*

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| Company | Comments |
| Panasonic | We agree this is RAN2 topic. |
| OPPO | We think even though the corresponding spec is in RAN2, RAN1 would need to discuss this issue to have a common understanding.  |
| Ericsson | It is not needed in our view, as RRC procedure delay is about UE processing time at the UE side. Anyway, this is a topic for RAN2 not for RAN1. |
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## 8.3 Updated proposal based on company views (1st round of email discussion)

To be added…

# 9 Issue #9: Timing relationship upon feeder link switch

## 9.1 Background

[Nokia, Nokia Shanghai Bell] propose to define timing relationships such that a feeder link switch does not cause a large jump in the common delay value used by the UE.

One item that needs further discussion is the impact of any feeder link switches on the timing relationships for NTN. Related topics have been proposed in [4]. As a guiding principle the reference point used for timing must not change as a consequence of the FL switch and as such it should not cause a jump in the common delay.

**Proposal 7: RAN1 to define timing relationships such that a feeder link switch does not cause a large jump in the common delay value used by the UE.**

In Moderator’s view, it is not clear how this can be achieved. The degree of common delay variation upon feeder link switch depends on the length difference of the first feeder link and the second feeder link, which in turn depends on the actual deployment of gateways and satellite constellation.

Further, it appears not an issue to have different delays before and after feeder link switch. For example, the network can configure UE to use different Koffset values for use before and after feeder link switch.

## 9.2 Company views

Based on the above discussion, an initial proposal is made as follows. Companies are encouraged to provide views on the proposal.

**Initial proposal 9.2-1 (Moderator):**

Discuss the necessity of the following proposal:

*[Nokia, Nokia Shanghai Bell] RAN1 to define timing relationships such that a feeder link switch does not cause a large jump in the common delay value used by the UE.*

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| Company | Comments |
| Panasonic | The issue is not clear. Might be solved by gNB implementation as commented by the moderator above.  |
| Ericsson | It would be better if proponent could clarify the proposal. |
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## 9.3 Updated proposal based on company views (1st round of email discussion)

To be added…

# References

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3. R1-2007323, Feature lead summary#4 on timing relationship enhancements, Moderator (Ericsson), 3GPP TSG RAN1 #102e, August 2020
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26. R1-2009152, Consideration on timing relationship enhancements, Spreadtrum Communications
27. R1-2009186, Discussion on timing relationship enhancements for NTN, NTT DOCOMO, INC.
28. R1-2009242, Views on DL-UL timing relationship for NTN operation, Nokia, Nokia Shanghai Bell
29. R1-2009262, Enhancements on Timing Relationship for NTN, Qualcomm Incorporated

# Appendix I: RAN1 agreements on timing relationship

**RAN1#102-e:**

Agreement:

* Introduce K\_offset to enhance the following timing relationships:
	+ 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 CSI reference resource timing.
	+ The transmission timing of aperiodic SRS.
* Note: Additional timing relationships that require K\_offset of the same or different values can be further identified.

Agreement:

For K\_offset used in initial access, the information of K\_offset is carried in system information.

* FFS implicit and/or explicit signaling of K\_offset in system information.
* FFS a cell specific K\_offset value used in all beams of a cell and/or each beam in a cell uses a beam-specific K\_offset value.
* FFS whether/how to update K\_offset after initial access.

# Appendix II: Summary of proposals

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| Tdoc | Source | Proposals |
| R1-2007569 | Huawei, HiSilicon | Proposal 1: Support implicit signaling of Koffset in system information.Proposal 2: A cell specific Koffset value is used for initial access.Proposal 3: Derive the initial Koffset from ra-ResponseWindow and an offset for the start of the ra-ResponseWindow.Proposal 4: Support updating of the Koffset from cell-specific to beam-specific after initial access. |
| R1-2007660 | vivo | Proposal 1: For a MAC CE command indicates to the UE about an action in DL or an assumption on the downlink configuration, the UE assumes the command is activated in the DL slot (at UE side) which is the first DL slot after the UL slot$ n+XN\_{slot}^{subframe,µ}+YN\_{slot}^{subframe,µ}$ , where the UL slot indexed by $n$ is the UL slot where UE transmits HARQ-ACK corresponding to the received PDSCH carrying the MAC CE command, and the value of Y is the common TA offset in the gNB's DL and UL frame timing.Proposal 2: For a MAC CE command indicates to the UE about an action in UL or an assumption on the uplink configuration, the UE assumes the command is activated in the UL slot (at UE side) $n+XN\_{slot}^{subframe,µ}+1$, where the UL slot indexed by $n$ is the UL slot where UE transmits HARQ-ACK corresponding to the received PDSCH carrying the MAC CE command.Proposal 3: For Koffset used in initial access, beam-specific Koffset is supported.Proposal 4: In NTN, cell-specific Koffset should also be supported.Proposal 5: After initial access procedure, there is no need to update Koffset if beam-specific Koffset is used in initial access procedure. |
| R1-2007854 | CATT | Proposal 1: K\_offset should be linked to TA compensation offset, rather than the whole RTD length. Proposal 2: The K\_offset should be explicit signaled in system information according to different scenarios.Proposal 3: The values of K\_offset can be notified within per-cell based on the SIB.Proposal 4: There is no need to update the K\_offset after initial access.Proposal 5: Expanding K1/K2 is not necessary.Proposal 6: For the MAC CE action timing, the parameter T should be equal to 3+RTD in NTN. |
| R1-2007991 | China Telecom | Proposal 1: The value of $K\_{offset}$ before random access is directly proportional to the maximum RTT of a beam, which is calculated based on the satellite’s ephemeris and the scope of the beam.Proposal 2: The value of $K\_{offset}$ is configured by the following two methods depending on the deployment,1. The gNodeB calculates the value of $K\_{offset}$ based on the maximum RTT and inform it to the UE through additional signaling, or,
2. The UE calculates the value of $K\_{offset}$ itself based on the TA value as a default configuration when the gNodeB does not inform it.
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| R1-2008010 | CMCC | Proposal 1: RAR windows related parameters can be derived from Koffset.Proposal 2: For Common TA based TA determining solution, only one of Common TA and Initial Koffset is explicitly indicated in system information. The following alternatives for further study* Alt 1 (i.e., Option 4b): Common TA is explicitly indicated in system information, while Initial Koffset is derived from Common TA as following
	+ Initial Koffset (in slot) = ⌈Common TA + maximum TA adjust range indicated by RAR⌉
* Alt 2: Initial Koffset is explicitly indicated in system information, while Common TA is derived from Initial Koffset as following
	+ Common TA = Initial Koffset - maximum TA adjust range indicated by RAR

Proposal 3: For TA determining solutions except for Common TA based one, Initial Koffset can be explicitly indicated in system information.Proposal 4: Beam specific indication for Initial Koffset and/or Common TA (i.e., each beam in a cell uses a beam-specific value) is supported.Proposal 5: For beam specific indication, cell specific system information with a list of beam-specific value to be repeated across beams as a baseline.Proposal 6: Further study beam specific system information, where each SI carries different beam-specific value.Proposal 7: Support Koffset update after initial access with extended K1/K2 value range.Proposal 8: Extend the value range of K1 to larger than 15, e.g., 31.Proposal 9: Discussion should be based on the assumption for aligned DL-UL timing at gNB side.Proposal 10: For aligned DL-UL timing at gNB side, conform the following understanding achieved in last meeting.* [UL MAC CE] For a MAC CE command received in DL slot n, where the command is used to indicate to the UE about an action in the UL or an assumption on the uplink configuration, the UE assumes the command is activated in the UL slot (at UE side) $n+k\_{1}+3N\_{slot}^{subframe,µ}+1$, where TA is assumed to be zero and the UL slot indexed by $n+k\_{1}$ is the UL slot where UE transmits HARQ-ACK corresponding to the received PDSCH carrying the MAC CE command.
* [DL MAC CE] For a MAC CE command received in DL slot n, where the command is used to indicate to the UE about an action in the DL or an assumption on the downlink configuration, the UE assumes the command is activated in the DL slot (at UE side) which is the first DL slot after the UL slot $n+k\_{1}+3N\_{slot}^{subframe,µ}$, where TA is assumed to be zero and the UL slot indexed by $n+k\_{1}$ is the UL slot where UE transmits HARQ-ACK corresponding to the received PDSCH carrying the MAC CE command.
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| R1-2008164 | Samsung | Proposal 1: The range of Koffset should depend on the maximum round trip propagation delay Trt and the maximum hop number L asKoffset ≥ L×Trtwhere Trt can be inferred from the broadcasting information.Proposal 2: Koffset is also applied to the determination of MAC CE activation timing.Proposal 3: More than one of above Koffset configurations can be supported, and using which one is dependent on gNB configuration.Proposal 4: The timing relationship for Configured Grant Type 1 should be left to Network implementation.Proposal 5: The timing relationship for Configured Grant Type 2 can follow the timing relationship for DCI scheduled PUSCH. |
| R1-2008253 | OPPO | Proposal 1: Support explicit configuration of cell-specific/beam-specific K\_offset in system information. Proposal 2: UE-triggered and gNB-controlled K\_offset updating can be considered. Proposal 3: K\_offset can be updated via RRC configuration or group-common DCI after initial access procedure. Proposal 4: For MAC-CE activation timing, X = max(3,K\_offset) ms.Proposal 5: K\_offset should be introduced to enhance the RRC procedure delay. Proposal 6: K\_offset should be introduced for SFI interpretation for an uplink BWP.  |
| R1-2008359 | Sony | Proposal 1: When the common TA is configured by gNB, the Koffset values should be implicitly defined by calculation at the UE from the common TA.Proposal 2: When the common TA is not configured by gNB in transparent payload case, the network should signal additional information such as gNB position or distance from the satellite to the UE.  |
| R1-2008410 | LG Electronics | Proposal 1: Support explicit signaling of K\_offset in system information.Proposal 2: Beam-specific K\_offset signaling is preferred. Proposal 3: Discuss whether and how to updated K\_offset value after initial access. Proposal 4: For the MAC-CE action timing, the corresponding action and the UE assumption on the downlink configuration indicated by the MAC-CE command shall be applied starting from the first slot that is after slot $n+XN\_{slot}^{subframe,µ}+K\_{offset}$ where X can be smaller than 3.  |
| R1-2008465 | Apple | Proposal 1: A cell specific $K\_{offset}$ is used in initial access. This cell specific $K\_{offset} $is explicitly indicated in system information.Proposal 2: A UE specific or a beam specific $K\_{offset}$ is used after initial access. Proposal 3: RAN1 strives to reduce the signaling overhead of updating $K\_{offset}$.Proposal 4: On MAC CE timing relationship, UE assumes UL MAC CE command is activated 3 ms after it transmits HARQ-ACK corresponding to a received PDSCH carrying the UL MAC CE command.Proposal 5: On MAC CE timing relationship, UE assumes DL MAC CE command is activated Y ms after it transmits HARQ-ACK corresponding to a received PDSCH carrying the DL MAC CE command. The value Y is equal to$ K\_{offset}^{'}+X$, where $K'\_{offset}$ is the absolute time converted from $K\_{offset}$ and X is less than 3 ms.Proposal 6: Introduce $K\_{offset}$ to the timing relationship for type 1 configured grant. |
| R1-2008722 | Fraunhofer IIS, Fraunhofer HHI | Proposal 1: It must be left to gNB/network to select a value of $K\_{offset}$ greater than or equal to the maximum RTD of cell or beam depending on cell specific or beam specific signaling. Proposal 2: RAN1 to adopt millisecond as the unit of the $K\_{offset}$. Proposal 3: NTN UE should derive the initial value of $K\_{offset}$ from the broadcast system information, e.g., ra-ContentionResolutionTimer and an offset to the start of ra-ContentionResolutionTimer or common/minimum delay. Proposal 4: NTN UE should derive the initial value of $K\_{offset}$ from the broadcast system information, e.g., RRC timers T300, T301, T319, and T310. Proposal 5: RAN1 to consider cell specific signaling of initial $K\_{offset}$.Proposal 6: The value of $K\_{offset}$ should be updated/reconfigure after RRC connection in UE specific manner. Proposal 7: For UE specific update of $K\_{offset}$, NTN UE should report its acquired TA to gNB.Proposal 8: NTN UE should report its first TA report as part of MSG3. Proposal 9: RAN1 to further study the details of NTN UE TA report.Proposal 10: RAN1 to further study the enhancement of 2-step RACH timing relationship for NTN.  |
| R1-2008808 | MediaTek Inc., Eutelsat | Proposal 1: Beam-specific Koffset corresponding to maximum RTD is broadcast on SIB for initial cell access. Whether Koffset is broadcast on SIB1 or on NTN-specific SIB is FFS. Proposal 2: UE reports its autonomously determined TA to the gNB. Proposal 3: Guard Period Around the start / end of UL transmission is configured.Proposal 4: K1 range are increased to 32 with indication of INTEGER (0..31) in dl-DataToUL-ACK field in PUCCH-Config.Proposal 5: K2 range are increased to 64 with indication of INTEGER (0..63) in PUSCH-TimeDomainResourceAllocation field in DCI .Proposal 6: For the MAC CE activation timing, MAC CE command is active Y ms after it transmits HARQ ACK corresponding to a received PDSCH carrying the MAC CE command, where Y = X + $K\_{offset}$ and X = 3.Proposal 7: The SFI-index field value in a DCI format 2\_0 is delayed by Koffset corresponding to maximum RTD in the beam. |
| R1-2008850 | ZTE | Proposal 1: The K\_offset derived from corresponding common TA value should be supported.Proposal 2: Beam-specific K\_offset configuration can be supported via common SIB or beam-specific SIB with following considerations:* + Multiple beam-specific values of K\_offset in single SIB.
	+ Different single value of K\_offset per beam in dedicated SIB.

Proposal 3: In case of indication of K\_offset, adaptive unit should be considered to support all scenarios with lower overhead. Proposal 4: Extension of existing offset (i.e., k, K1, K2) should be supported.Proposal 5: Taking following principles as the basis for MAC CE timing relationship discussion:* The MAC CE (except for the TA command)can only be applied once the ACK/NACK is received at gNB side
* Slot n for ACK/NACK transmission at UE side is determined by previous scheduling instead of real time instant for transmission with applied TA.

Proposal 6: For the MAC CE action timing, the existing value of X, i.e., X = 3, can be reused in NTN.Proposal 7: For the 2-step RACH, introduce K\_offset for the transmission timing of fallback random-access response (RAR) scheduled PUSCH and HARQ-ACK feedback for Msg-B. |
| R1-2008922 | Lenovo, Motorola Mobility | Proposal 1: MAC CE activation delay is determined by the gNB UL-DL timing shift.Proposal 2: DCI 2-0 application delay should be determined by twice the propagation delay between gNB and UE if uplink slot/symbol is indicated by DCI 2-0.Proposal 3: Consider slot format ending with several F slot/symbols.Proposal 4: Support per beam indication of Koffset.Proposal 5: Support extending the range of K1 value.Proposal 6: The Koffset indication in broadcast signaling or RRC signaling depends on the UE status and scenarios. |
| R1-2008989 | Intel Corporation | Proposal 1: * If TA corresponds to UE-gNB round trip delay
	+ For the MAC CE action timing, the corresponding action and the UE assumption on the downlink configuration indicated by the MAC-CE command shall be applied starting from the first slot that is after slot $n+3N\_{slot}^{subframe,µ}$, where n is target slot for the HARQ-ACK transmission (without TA)
* If TA corresponds to service link round trip delay (feeder link delay is not considered for TA)
	+ For the MAC CE action timing, the corresponding action and the UE assumption on the downlink configuration indicated by the MAC-CE command shall be applied starting from the first slot that is after slot $n+3N\_{slot}^{subframe,µ}+K\_{MAC CE}$, where n is target slot for the HARQ-ACK transmission (without TA), $K\_{MAC CE}$ is configured by higher layers

Proposal 2: * Common timing advance (TA) value can be used to determine common slot offset (Koffset) if common TA indication is supported
* Beam-specific indication of Koffset value should be supported
* Koffset value should be common for all applicable physical layer procedures
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| R1-2009015 | ETRI | Proposal 1: In the initial access, Koffset can be configured regardless of the configuration of the common TA. Koffset can be the maximum value of the RTT of the service link.Proposal 2: In the initial access, Koffset can be broadcast through SIB as a beam-specific parameter.Proposal 3: A UE-specific parameter can be configured for Koffset update. In order to adjust Koffset for the UE, a difference value between the beam-specific Koffset configured for initial access and the value reflecting the UE-specific TA can be transmitted to the UE. |
| R1-2009032 | Xiaomi | Proposal 1: Different Koffset value is applied to the activation of MAC CE.Proposal 2: Koffset is configured on a per beam basis.Proposal 3: It is preferred to have common signaling to update the Koffset.Proposal 4: The Koffset is configured with a unit of millisecond. |
| R1-2009049 | Panasonic Corporation | Proposal 1: UE-specifically update Koffset after initial access.Proposal 2: Support indication of relative Koffset value via MAC CE or group common DCI.Proposal 3: Beam specific Koffset is not supported. Proposal 4: - MAC CE action timing related to UL transmission should be 3 slots after HARQ-ACK transmission slot for the PDSCH containing the MAC CE. - MAC CE action timing related to DL status should be defined based on an offset from the reception timing of PDSCH containing the MAC CE.  |
| R1-2009057 | Asia Pacific Telecom co. Ltd | Proposal 1 Different MAC CE action time based on MAC CE types shall be supported in NTNProposal 2 Do not introduce K\_offset for MAC CE action time.Proposal 3 To prevent the MAC CE action time before the HARQ-ACK that NW receives, MAC CE action time based on the NW timeline shall be considered.Proposal 4 The term of $NTA,max $used for TA command MAC CE shall be further enhanced.Proposal 5 Timing enhancement on 2-step RACH shall start in RAN1#103-e.Proposal 6 Signaling on K\_offset in initial access shall be explicit or RAN1 shall wait for more progress on Msg3 scheduling in RAN2. |
| R1-2009076 | CAICT | Proposal 1: In NTN, SFI-index field value in a DCI format 2\_0 indicates slot format for a number of slots starting from the slot which is at least $K\_{offset}$ slots after the UE detects the DCI format 2\_0.Proposal 2: When a RACH procedure is trigged by PDCCH order, UE shall select the next available RO after a timing offset according to the indication of PDCCH order, where the timing offset can be indicated explicitly or implicitly.Proposal 3: Explicit signal of $K\_{offset}$ in the system information. gNB has the flexibility of configuring cell-specific or beam specific value of $K\_{offset}$.Proposal 4: To support updating $K\_{offset}$ after initial access. The value of $K\_{offset}$ corresponds to UE-specific TA.Proposal 5: UE reports its autonomous TA to the gNB when the corresponding value of $K\_{offset}$ is to be changed at the UE side.Proposal 6: To enhance K1/K2 indication with explicit or implicit way in TDD system which is with more contiguous DL slots. Proposal 7: Confirm the previous understanding of existing MAC CE timing.Proposal 8: Have the following enhancements on the MAC CE timing in NTN：* [UL MAC CE] For a MAC CE command received in DL slot n, where the command is used to indicate to the UE about an action in the UL or an assumption on the uplink configuration,
	+ If UL transmission corresponding to the MAC CE command is independent of instantons DL scheduling, the UE assumes the command is activated in the UL slot (at UE side) $n+k\_{1}+3N\_{slot}^{subframe,µ}+1$, where TA is assumed to be zero and the UL slot indexed by $n+k\_{1}$ is the UL slot where UE transmits HARQ-ACK corresponding to the received PDSCH carrying the MAC CE command.
	+ If UL transmission corresponding to the MAC CE command depends on instantons DL scheduling, the UE assumes the command is activated in the UL slot (at UE side) $n+k\_{1}+K\_{offset}+XN\_{slot}^{subframe,µ}+1$, where TA is applied and the UL slot indexed by $n+k\_{1}$ is the UL slot where UE transmits HARQ-ACK and the corresponding to the received PDSCH carrying the MAC CE command.
* [DL MAC CE] For a MAC CE command received in DL slot n, where the command is used to indicate to the UE about an action in the DL or an assumption on the downlink configuration, the UE assumes the command is activated in the DL slot (at UE side) which is the first DL slot after the UL $n+k\_{1}+K\_{offset}+XN\_{slot}^{subframe,µ}+1$,, where TA is applied and the UL slot indexed by $n+k\_{1}$ is the UL slot where UE transmits HARQ-ACK corresponding to the received PDSCH carrying the MAC CE command.
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| R1-2009091 | Ericsson | Proposal 1 The value of $K\_{offset}$ used in initial access is signaled explicitly in system information.Proposal 2 The value of $K\_{offset}$ used in initial access is cell specific.Proposal 3 The value of $K\_{offset}$ can be reconfigured after RRC connection setup to be UE specific for unicast scheduling.Proposal 4 RAN1 discussion on MAC CE timing relationships is only relevant for those MAC CEs that involve timing relationships defined in the physical layer specifications.Proposal 5 General MAC CE timing relationship discussions are assumed to be applicable to those MAC CEs that involve “3 ms application delay” defined in the physical layer specifications.Proposal 6 Exceptional MAC CE timing relationships where the general discussion is not applicable may be discussed case by case based on company input.Proposal 7 RAN1 should determine suitable MAC CE activation times for e.g. TCI states and spatial relations to support beam change.Proposal 8 Downlink and uplink frame timing are assumed to be aligned at gNB in Rel-17 NTN. In other words, downlink and uplink frame timing are offset by no more than a small fraction of a slot.Proposal 9 If Proposal 8 is not agreeable: [DL MAC CE] When the gNB UL timing is delayed by an offset of Y ms relative to its DL timing, for a MAC CE command received in DL slot n, where the command is used to indicate to the UE about an action in the DL or an assumption on the downlink configuration, the UE assumes the command is activated in the DL slot (at UE side) which is the first DL slot after the UL slot $n+k\_{1}+(3+Y)N\_{slot}^{subframe,µ}$, where TA is assumed to be zero and the UL slot indexed by $n+k\_{1}$ is the UL slot where UE transmits HARQ-ACK corresponding to the received PDSCH carrying the MAC CE command. |
| R1-2009116 | InterDigital, Inc. | Proposal 1: support K-offset for MAC-CE action timingProposal-2: K-offset value is independently determined/indicated from common TA in the system information (Alt-1)Proposal-3: support explicit indication of K-offset and beam-specific K-offset indicationProposal-4: support to update the K-offset to a UE-specific delay after initial access and it is up to the network to use UE-specific K-offset |
| R1-2009152 | Spreadtrum Communications | Proposal 1: Explicit signaling of K\_offset used in initial access in system information should be considered.Proposal 2: Beam-specific values of K\_offset configuration for initial access should be supported.Proposal 3: UE updates the value of K\_offset based on predefined rules should be considered. |
| R1-2009186 | NTT DOCOMO, INC. | Proposal 1: $K\_{offset}$ is signaled in SIB1 or in SIB following SIB1. Proposal 2: $K\_{offset}$ in initial access is a cell-specific parameter.Proposal 3: Support the value of $K\_{offset}$ in initial access which corresponds to the largest delay in the cell. |
| R1-2009242 | Nokia, Nokia Shanghai Bell | Proposal 1: In order to minimize specification efforts, RAN1 to decide a single combination option for synchronization reference point and long/short TA. Proposal 2: RAN1 to discuss the understanding of MAC-CE action timing for both the long TA and short TA cases to identify which scenario requires changes to specifications (if any). Proposal 3: The UL-DL timing relationships adjustments should be dynamic to follow the propagation variation over time. Proposal 4: RAN1 to discuss if UE-specific values for $K\_{NTN}$ can be specified in complement to the cell base $K\_{NTN}.$Proposal 5: K\_offset applied by the UE to the timing relationships can be updated after initial access.Proposal 6: RAN1 to discuss signalling multiple K\_offset or $K\_{NTN}$ values in a non-UE specific way which are used to update the UE applied value over time. Proposal 7: RAN1 to define timing relationships such that a feeder link switch does not cause a large jump in the common delay value used by the UE. |
| R1-2009262 | Qualcomm Incorporated | Proposal 1: * Introduce Koffset for the following timing relationship:
	+ When the HARQ-ACK corresponding to a PDSCH carrying a MAC-CE command is transmitted in slot $n$, the corresponding action and the UE assumption on the downlink configuration indicated by the MAC-CE command shall be applied starting from the first slot that is after slot $n+XN\_{slot}^{subframe,µ}+K\_{offset}$ (the value of X is FFS), where $N\_{slot}^{subframe,µ}$ denotes the number of slots per subframe for subcarrier spacing configuration $μ$.
* FFS if the above Koffset is applied to PRACH transmission.
* Note that the above does not preclude the use of the same Koffset value as that for DCI scheduled PUSCH.

Proposal 2: Support UE specific Koffset based on UE TA report(s).* Exact mechanisms for UE TA report and associated signalling of Koffset are FFS.
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