3GPP TSG-RAN WG1 Meeting #102-e R1-20xxxxx

e-Meeting, August 17th – 28th, 2020

Agenda Item: 8.4.1

Source: Moderator (Ericsson)

Title: Feature lead summary 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#102-e under agenda item 8.4.1 [3] – [23].

# 1 Issue #1: Timing relationships that need Koffset

## 1.1 Background

During the Rel-16 NTN SI, it was identified that an offset $K\_{offset}$ can be introduced to enhance several timing relationships as listed below [1].

* For the transmission timing of DCI scheduled PUSCH (including CSI on PUSCH), the slot allocated for the PUSCH can be modified to be $\left⌊n⋅\frac{2^{μ\_{PUSCH}}}{2^{μ\_{PDCCH}}}\right⌋+K\_{2}+K\_{offset}$.
* For the transmission timing of RAR grant scheduled PUSCH, the UE transmits the PUSCH in slot $n + K\_{2} +Δ+K\_{offset}$.
* For the transmission timing of HARQ-ACK on PUCCH, the UE provides corresponding HARQ-ACK information in a PUCCH transmission within slot $n+K\_{1}+K\_{offset}$.
* 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}$$n+3N\_{slot}^{subframe,µ}+K\_{offset}$, where the value of $X$ may depend on NTN UE capability and may not necessarily be equal to $3$. How to determine the value of $X$ is for further study.
* For the CSI reference resource timing, the CSI reference resource is given in the downlink slot $n-n\_{CSI\_{ref}}-K\_{offset}$.
* For the transmission timing of aperiodic SRS, the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in slot $\left⌊n∙2^{\frac{μ\_{SRS}}{μ\_{PDCCH}}}\right⌋+k+K\_{offset}$.

To recap the necessity of introducing $K\_{offset}$, let us consider PUSCH scheduling timing relationship as an example. When the UE is scheduled to transmit PUSCH by a DCI, the DCI indicates the slot offset *K2* among other things. The slot allocated for the PUSCH is $\left⌊n⋅\frac{2^{μ\_{PUSCH}}}{2^{μ\_{PDCCH}}}\right⌋+K\_{2}$, where *n* is the slot with the scheduling DCI, and *K2* is based on the numerology of PUSCH, and $μ\_{PUSCH}$ and $μ\_{PDCCH}$ are the subcarrier spacing configurations for PUSCH and PDCCH, respectively.



Note that the scheduling timing is defined by assuming uplink TA is zero. The scheduler needs to take into account appropriate timing constraints due to the minimum UE processing time when indicating timing, as illustrated by the figure below.



So, when TA becomes large, the cardinality of the set of values of K2 that can be used is reduced significantly or even becomes zero. Similar issues exist in several other timing relationships as well. Accordingly, during the Rel-16 NTN SI, it was identified that an offset $K\_{offset}$ can be introduced to enhance timing relationships.

Based on the proposals submitted to RAN1#102-e, there is no objection to introduce $K\_{offset}$ to enhance timing relationships. Several companies explicitly propose to confirm the types of timing relationships that need $K\_{offset}$.

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| **Tdoc** | **Source** | **Proposals** |
| [**R1-2005495**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005495.zip) | MediaTek Inc. | **Proposal 1**: For UL transmission timing, introduce an offset Koffset for NR NTN.* For UL HARQ-ACK on PUCCH, where HARQ ACK on PUCCH is transmitted on slot n + K1 + Koffset when a scheduling DCI is received in slot n.
* For UL transmission on PUSCH, where PUSCH is transmitted on slot $\left⌊n∙2^{μ\_{PUSCH}-μ\_{PDCCH}}\right⌋+K\_{2}+K\_{offset}$ when a scheduling DCI is received in slot n.
* For CSI transmission on PUSCH, where CSI on PUSCH is transmitted on slot n +K+Koffset, when the DCI with CSI request is received in slot n and K is selected by the DCI.
* For a CSI report in uplink slot n’, the CSI reference resource is given in downlink slot n-nCSI\_ref$-K\_{offset}$, where  and nCSI\_ref is as defined in 38.214.
* With reference to slots for a PUSCH transmission scheduled by a RAR UL grant, if a UE receives a PDSCH with a RAR message ending in slot $n$ for a corresponding PRACH transmission from the UE, the UE transmits the PUSCH in slot $n + K\_{2} +Δ+K\_{offset}$.
* 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}$$n+3N\_{slot}^{subframe,µ}+K\_{offset}$ (X can be determined when specifications are developed).
* If a UE receives a DCI triggering aperiodic SRS in slot n, the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in slot $⌊n∙2^{\frac{μ\_{SRS}}{μ\_{PDCCH}}}⌋+k+K\_{offset}$.
* Koffset is per beam or per-cell
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| [**R1-2005548**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005548.zip) | Fraunhofer IIS, Fraunhofer HHI | **Proposal 1**: RAN1 to check if the given list for impacted clauses is complete and needs to be captured.  |
| [**R1-2005873**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005873.zip) | Intel Corporation | **Proposal 1**: * Support additional slot offset Koffset for the following cases
	+ For the transmission timing of DCI scheduled PUSCH (including CSI on PUSCH)
	+ For the transmission timing of RAR grant scheduled PUSCH
	+ For the transmission timing of HARQ-ACK on PUCCH
	+ For the CSI reference resource timing
	+ For the transmission timing of aperiodic SRS
* The values of Koffset are broadcasted by the gNB per beam

**Proposal 2**: * 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)
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| [**R1-2006210**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006210.zip) | CMCC | **Proposal 3**: Conform the following timing relations enhancement as discussed in TR 38.821 at NTN work item,* Transmission timing for PUSCH scheduled by DCI
* Transmission timing for CSI on PUSCH
* Transmission timing for PUSCH scheduled by RAR grant
* Transmission timing for HARQ-ACK on PUCCH
* CSI reference resource timing
* Aperiodic SRS transmission timing

**Proposal 4**: Further discussion on the timing relationships enhancement for MAC CE action timing in NTN. |
| [**R1-2006325**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006325.zip) | Panasonic Corporation | **Proposal 1**: In addition to cell/beam specific Koffset for timing relationship on DCI scheduled PUSCH, HARQ-ACK on PUCCH and aperiodic SRS, UE specific control, Koffset,UE, should be introduced. When the network has the UE location or UE autonomous TA information, the network can use it.**Proposal 2**: To clarify the MAC CE reflection timing of DL status is after the timing gNB receives HARQ-ACK.**Proposal 3**: The same offset value as UL transmission timing, Koffset and Koffset,UE, is applied to the timing relationship for the CSI reference resource. |
| [**R1-2006421**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006421.zip) | Nokia, Nokia Shanghai Bell | **Proposal 2**:The offset factor, $K\_{NTN}$, should be applicable for all UL-DL timing relationships.  |
| [**R1-2006804**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006804.zip) | Qualcomm Incorporated | **Proposal 1**: * The value of timing delay, *K*offset, is broadcasted per cell or per beam and is applied as in the following timing relationships:
	+ For UL HARQ-ACK on PUCCH in response to a scheduling DCI received in slot n , UE transmits the HARQ ACK on PUCCH on slot n + K1 + Koffset .
	+ When a scheduling DCI of a PUSCH is received in slot n, UE transmits the PUSCH on slot $\left⌊n∙2^{μ\_{PUSCH}-μ\_{PDCCH}}\right⌋+K\_{2}+K\_{offset}$.
	+ When a DCI with CSI request is received in slot n and K is selected by the DCI, UE transmits CSI on PUSCH on slot n +K+Koffset, where K is indicated by the DCI.
	+ For a CSI report in uplink slot n’, the CSI reference resource is given in downlink slot n-nCSI\_ref$-K\_{offset}$, where  and nCSI\_ref is as defined in 38.214.
	+ With reference to slots for a PUSCH transmission scheduled by a RAR UL grant, if a UE receives a PDSCH with a RAR message ending in slot $n$ for a corresponding PRACH transmission from the UE, the UE transmits the PUSCH in slot $n + K\_{2} +Δ+K\_{offset}$.
	+ 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}$$n+3N\_{slot}^{subframe,µ}+K\_{offset}$ (the value of X is FFS).
	+ If a UE receives a DCI triggering aperiodic SRS in slot n, the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in slot $⌊n∙2^{\frac{μ\_{SRS}}{μ\_{PDCCH}}}⌋+k+K\_{offset}$.
* Additional configuration and mechanisms can be considered to overwrite the value for one or more of the above relationships.
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## 1.2 Company views

From the proposals above, it appears sensible to agree on the introduction of $K\_{offset}$ at least for 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.

There are proposals to clarify the use of $K\_{offset}$ in MAC CE timing relationship. There are also proposals (not summarized in the above table) on introducing $K\_{offset}$ in additional timing relationships. These proposals are summarized as additional issues below and can be further discussed in Rel-17.

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

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

* 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 $K\_{offset}$ can be further identified.

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| Company | Comments |
| Ericsson | Support the proposal 1-1. |
| MediaTek | Support the proposal 1-1. |
| QC | Support with the following suggested change in note:Note: Additional timing relationships that require $K\_{offset}$ of the same or different values can be further identified.We also believe a Koffset is needed for MAC-CE, see comments for proposal 3-1. |
| Lenovo/MM | Support the proposal 1-1. |
| CMCC | Support the proposal 1-1. |
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## 1.3 Updated proposal based on company views

To be added…

# 2 Issue #2: Configuration of Koffset

## 2.1 Background

Based on the contributions submitted to RAN1#102-e, there are diverse proposals on how to configure $K\_{offset}$.

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| **Tdoc** | **Source** | **Proposals** |
| [**R1-2005265**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005265.zip) | Huawei, HiSilicon | **Proposal 1**: RAN1 strives for a unified signaling framework to support “full TA” and “partial TA”.**Proposal 2**: Derive the initial cell-specific Koffset from broadcast information, e.g., ra-ResponseWindow and an offset for the start of the ra-ResponseWindow.**Proposal 3**: To reduce the scheduling delay, support updating Koffset from cell-specific to beam-specific. |
| [**R1-2005495**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005495.zip) | MediaTek Inc. | **Proposal 1**: …* Koffset is per beam or per-cell

**Proposal 3**: Beam-specific Koffset based on Maximum RTT for scheduling of Message 3 is broadcast on SIB  |
| [**R1-2005548**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005548.zip) | Fraunhofer IIS, Fraunhofer HHI | **Proposal 3**: Adopt $K\_{offset}$ according to the UE specific TA.**Proposal 4**: Broadcast the value of $K\_{offset}$ based on (2) as part of SIB. |
| [**R1-2005573**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005573.zip) | Sony | **Proposal 1**: When the common TA is configured by gNB, the Koffset values should be calculated at the UE from the common TA. |
| [**R1-2005706**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005706.zip) | CATT | **Proposal 2**: The values of $K\_{offset}$ should be notified within per-beam/per-cell based on the SIB. |
| [**R1-2005833**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005833.zip) | Lenovo, Motorola Mobility | **Proposal 1**: Support per beam indication of Koffset.**Proposal 3**: At least broadcast signaling is supported. Dedicated higher layer signaling can be FFS. |
| [**R1-2005873**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005873.zip) | Intel Corporation | **Proposal 1**: * The values of Koffset are broadcasted by the gNB per beam
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| [**R1-2005963**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005963.zip) | ZTE | **Proposal 2**: The Koffset for all UEs should be derived from corresponding common TA value.**Proposal 6**: In case of indication on the offset, i.e., common offset and UE specific offset, proper setting of the unit should be considered to support all scenarios with lower overhead.  |
| [**R1-2006029**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006029.zip) | OPPO | **Proposal 1**: Cell-specific, UE-specific are group-UE specific timing offset configuration can be considered. **Proposal 2**: Koffset updating can consider UE triggered and gNB controlled manners.  |
| [**R1-2006144**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006144.zip) | 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. |
| [**R1-2006210**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006210.zip) | CMCC | **Proposal 5**: Default timing offset ($K\_{offset}^{default}$), which is determined by common TA and maximum possible TA adjustment range indicated by RAN, can be used for random access procedure and/or RRC connection re-establish procedure.**Proposal 6**: After RRC connection setup, UE specified timing offset ($K\_{offset}$) may be signaled by higher layers. |
| [**R1-2006325**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006325.zip) | Panasonic Corporation | **Proposal 1**: In addition to cell/beam specific Koffset for timing relationship on DCI scheduled PUSCH, HARQ-ACK on PUCCH and aperiodic SRS, UE specific control, Koffset,UE, should be introduced. When the network has the UE location or UE autonomous TA information, the network can use it. |
| [**R1-2006358**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006358.zip) | ETRI | **Proposal 3**: $K\_{offset}$ may be configured through an expansion of the resource indicator field of NR or a new parameter field. If it is configured with a new parameter field, it may be configured as a table similar to the resource indicator field of NR. |
| [**R1-2006378**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006378.zip) | LG Electronics | **Proposal 1**: K\_offset per beam is independently configured by high-layer.**Proposal 2**: Discuss whether and how to updated K\_offset value.  |
| [**R1-2006421**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006421.zip) | Nokia, Nokia Shanghai Bell | **Proposal 3**: $K\_{NTN}$must be available before the UE random access, for example, indicated by broadcast messages by the gNB. **Proposal 4**: The UL-DL timing relationships adjustments should be dynamic to follow the propagation variation over time. **Proposal 5**: RAN1 to discuss if UE-specific values for $K\_{NTN}$ can be specified in complement to the cell base  |
| [**R1-2006464**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006464.zip) | Ericsson | **Proposal 5** The value of $K\_{offset}$ is signaled at least in SIB1 and is cell specific.**Proposal 6** The value of $K\_{offset}$ can be reconfigured for each UE after RRC connection setup to be UE specific for unicast scheduling. |
| [**R1-2006519**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006519.zip) | Apple | **Proposal 1**: The UE-specific $K\_{offset}$ is equal to full TA, divided by slot duration.  |
| [**R1-2006589**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006589.zip) | Beijing Xiaomi Mobile Software | **Proposal 1**: If UE-specific differential TA compensation is applied at UE side, the Koffset could be configured as the max differential RTT offset.**Proposal 2**: If full TA compensation is applied at UE side, the Koffset could be configured as the max RTT.**Proposal 3**: The Koffset can be transmitted in the SIB. |
| [**R1-2006640**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006640.zip) | Asia Pacific Telecom co. Ltd | **Proposal 1** For Earth moving cells, set K\_offset as a fixed value per cell.**Proposal 2** For Earth fixed cells, signalling on K\_offset update shall be FFS. |
| [**R1-2006804**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006804.zip) | Qualcomm Incorporated | **Proposal 1**: * The value of timing delay, *K*offset, is broadcasted per cell or per beam and is applied as in the following timing relationships:
	+ [DETAILS OMIITED HERE]
* Additional configuration and mechanisms can be considered to overwrite the value for one or more of the above relationships.

**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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| [**R1-2006855**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006855.zip) | CAICT | **Proposal 3**: To consider the value of $K\_{offset}$ be UE-specific and corresponds to the value of timing advance to modify the relevant timing relationships between each kind of DL-UL timing interaction. |

There are also some proposals on details of design, such as unit of $K\_{offset}$, value range of $K\_{offset}$, etc. These proposals can be discussed after the main design has been anchored.

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| **Tdoc** | **Source** | **Proposals** |
| [**R1-2005548**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005548.zip) | Fraunhofer IIS, Fraunhofer HHI | **Proposal 2**: RAN1 to decide on the unit of the values of $K\_{offset}$**.**. |
| [**R1-2006464**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006464.zip) | Ericsson | **Proposal 3** The unit of $K\_{offset}$ is specified in terms of millisecond. For each identified timing relationship that needs to be modified for NTN, the value of $K\_{offset}$ is translated into a number of slots by multiplying the value with $2^{μ}$, where is the corresponding numerology of the slot numbering in the identified timing relationship.**Proposal 4** The value range of $K\_{offset}$ is 1, 2, …, 600 ms. |
| [**R1-2006589**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006589.zip) | Beijing Xiaomi Mobile Software | **Proposal 4**: The Koffset is configured with a unit of millisecond. |

## 2.2 Company views

The main role of $K\_{offset}$ is to handle the offset between the UE’s DL and UL frame timing in NTN, and the value of $K\_{offset}$ would depend on the magnitude of timing advance (TA) that the UE would perform. The TA mechanisms (full TA, common TA, differential TA, etc.) in NTN can be quite diverse. It is sensible to have a unified signaling framework to support “full TA” and “partial TA”.

Broadcasting $K\_{offset}$ is necessary as it would need to be used for UE’s initial access procedure. There are different views whether the broadcasted $K\_{offset}$ should be cell specific or beam specific.

Further, there are many supports that the $K\_{offset}$ can be updated by UE specific RRC besides broadcasting $K\_{offset}$. Updating $K\_{offset}$ by UE specific RRC can make the timing relationship more tailored to UE and thus the scheduling would be more efficient.

It is necessary to distinguish which timing relationship(s) use the value of $K\_{offset}$ broadcasted in system information and the value of $K\_{offset}$ configured in UE specific RRC. In general, it appears reasonable to use the value of $K\_{offset}$ configured in UE specific RRC for unicast scheduling and the value of $K\_{offset}$ broadcasted in system information for non-unicast purpose.

There are also other proposals such as deriving the initial cell-specific $K\_{offset}$ from broadcast information, e.g., ra-ResponseWindow and an offset for the start of the ra-ResponseWindow.

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

**Initial proposal 2-1 (Moderator):**

For the value of $K\_{offset}$ used at least in initial access, down-select one option from below:

* Option 1: A cell-specific value of $K\_{offset}$ is configured in system information.
* Option 2: One or more beam-specific values of $K\_{offset}$ are configured in system information.
* Option 3: $K\_{offset}$ is equal to UE specific TA.
* Option 4: $K\_{offset}$ is equal to common TA.
* Option 5: A cell-specific $K\_{offset}$ is derived based on ra-ResponseWindow and an offset for the start of the ra-ResponseWindow in system information.

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| Company | Comments |
| Ericsson | Support Option 1.* Comment on Option 2: Considering an NR cell may support many beams (e.g. up to 64 beams in FR2), broadcasting many $K\_{offset}$ values in system information may result in much signaling overhead. Further, the same system information would need to be repeated across the beams.
* Comment on Options 3 – 4: It appears more flexible and cleaner to have $K\_{offset}$ to be independently configured from TA. To support the diverse TA scenarios, the value of $K\_{offset}$ does not have to be tied to TA. And it is up to the network to configure $K\_{offset}$ as appropriate.
* Comment on Option 5: such coupling restricts configuration flexibility and its benefit is not clear. In addition, this would introduce dependency on RAN2 progress.
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| MediaTek | Support options 1 and 3. Option 3 would require UE to report its autonomous TA ,with the following benefits * Configuration of MAC timers for power consumption as discussed in RAN2 (ref MediaTek R2-2006638).
* Avoid subframe boundaries overlap between UEs in connected mode, higher gNB scheduler flexibility
 |
| QC | Support Options 1 and 2 with suggested texts:Option 2: A value of Koffset is configured per beam or per cell in system information. Signaling of Koffset per cell or per beam should be left to deployment/implementation. Overhead issue can be considered at the time of signaling design.Option 3 may not work unless TA reporting is supported and should not be used as the default mechanism. |
| CMCC | Recommend amending Option 4 to Option 4b as following:* Option 4b: $K\_{offset}$ is derived from beam-specific common TA.

Support Option 2 and Option 4b * Comment on Option 1: cell-specific $K\_{offset}$ seems too large to increase the end-to-end latency.
* Comment on Option 2: Compared to Option 1, beam-specific $K\_{offset}$ is more tailored to UE. Furthermore, if beam-specific system information is considered, broadcasting beam-specific $K\_{offset}$ in system information may not increase signaling overhead, since in NTN scenario one UE is served only by one satellite spot beam for a long duration, and it does not need to receive system information of other beams.

Comment on Option 4b: Compared to Option 2, implicitly derivation of $K\_{offset}$ from beam-specific common TA can be considered to save signaling overhead. For example, $K\_{offset}$ may be determined via beam-specific common TA and maximum possible TA adjustment range indicated by RAN. |
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**Initial proposal 2-2 (Moderator):**

The value of $K\_{offset}$ can be updated by UE specific RRC.

* FFS the timing relationships that use the updated $K\_{offset}.$

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| Company | Comments |
| Ericsson | Support the proposal 2-2. |
| MediaTek | Proposal 2-2 could be one implementation method for option 3 in Proposal 2-1. The Koffset value updated by dedicated signaling could be based on UE report of its autonomous TA.  |
| QC | Support. |
| Lenovo/MM | Support extension of K1/K2. |
| CMCC | Support the proposal 2-2.$K\_{offset}$ can be updated by dedicated RRC signaling, but considering RTT may be rapidly changed in LEO scenario, frequent update with dedicated RRC signaling is not desired, and it is suggested to enlarge K1/K2 value range to enable flexibly changing of timing relationship via DCI, which may reduce RRC signaling overhead for frequently updating $K\_{offset}$. |
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## 2.3 Updated proposal based on company views

To be added…

# 3 Issue #3: MAC CE timing relationship

## 3.1 Background

During the Rel-16 NTN SI, it was identified that an offset $K\_{offset}$ can be introduced to enhance MAC CE timing relationship as quoted below.

**TR 38.821, Section 6.2.1.1: Background**

* MAC CE action timing: 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 $n+3N\_{slot}^{subframe,µ}$ , where $N\_{slot}^{subframe,µ}$ denotes the number of slots per subframe for subcarrier spacing configuration .

**TR 38.821, Section 6.2.1.2: Enhancements**

* 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}$$n+3N\_{slot}^{subframe,µ}+K\_{offset}$, where the value of $X$ may depend on NTN UE capability and may not necessarily be equal to $3$. How to determine the value of $X$ is for further study.

There are several proposals on the need of clarifying MAC CE timing relationship.

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| **Tdoc** | **Source** | **Proposals** |
| [**R1-2005873**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005873.zip) | Intel Corporation | **Proposal 2**: * 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)
 |
| [**R1-2006210**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006210.zip) | CMCC | **Proposal 4**: Further discussion on the timing relationships enhancement for MAC CE action timing in NTN. |
| [**R1-2006325**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006325.zip) | Panasonic Corporation | **Proposal 2**: To clarify the MAC CE reflection timing of DL status is after the timing gNB receives HARQ-ACK. |

Regarding the value of X, there are several proposals as well. A first proposal is to use existing value of 3 ms. A second proposal is to allow NTN UE to report its capability, considering e.g. that NTN UE may have different TCI/beam activation times depending on the UE’s antenna type (e.g. mechanically vs. electronically steerable antenna). A third proposal is to use a value smaller than 3 ms. These proposals can be discussed once the timing relationship issue is first clarified.

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| **Tdoc** | **Source** | **Proposals** |
| [**R1-2005963**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005963.zip) | ZTE | **Proposal 7**: For the MAC CE action timing, the existing value of X , i.e., X = 3, can be reused in NTN. |
| [**R1-2006464**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006464.zip) | Ericsson | **Proposal 7** NTN UE can report its capability in terms of MAC CE action timing application delay.**Proposal 8** RAN1 should determine suitable MAC CE activation times for e.g. TCI states and spatial relations to support beam change. |
| [**R1-2006519**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006519.zip) | Apple | **Proposal 2**: For MAC CE action timing, the value X is smaller than 3.  |

## 3.2 Company views

Note that the specifications are written from UE’s perspective. The fundamental confusion comes when a UE can assume that a MAC CE command becomes active. The detailed timing relationship description can be determined once the confusion is sorted out.



The above figure illustrates two options:

* Option 1: UE assumes MAC CE command is active X ms after it transmits HARQ ACK corresponding to a received PDSCH carrying the MAC CE command.
* Option 2: UE assumes 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 + round-trip delay. The round-trip delay can be configured using $K\_{offset}$.

Option 1 is simpler, but it ignores the fact that HARQ ACK for MAC CE is used to achieve synchronization between gNB and UE. It may lead to different assumptions between gNB and UE.

Option 2 is more aligned with existing MAC CE framework, allowing for synchronization between gNB and UE about the MAC CE. But it has longer application latency.

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

**Initial proposal 3-1 (Moderator):**

On MAC CE timing relationship, down-select one option from below:

* Option 1: UE assumes MAC CE command is active X ms after it transmits HARQ ACK corresponding to a received PDSCH carrying the MAC CE command.
* Option 2: UE assumes 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 + $K\_{offset}$.

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| Company | Comments |
| Ericsson | Support Option 2, which was the intended option when MAC CE timing relationship was discussed in Rel-16 NTN SI. |
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| QC | Don’t support and believe a Koffset is needed.The above two options can cause a period of confusion between network and UE as UE’s exact transmission time may not be known to the network. In addition* Proposal 1 and proposal 3-1 are related to timing reference point. One option, as some have suggested, is to have gNB as the timing reference point, i.e., DL and UL frame timing aligned at gNB. This may not work in NTN where inter-satellite links can exist and DL and UL may even go through different satellites. Another option is to have the satellite that UE connected to as the reference point. In such case, TA only covers the round trip of the service link and so does the Koffset of the timing relationships identified in proposal 1.
* For MAC-CE associated with DL configurations, it has to be applied after network receives the associated HARQ-ACK. For this reason, if Koffset for the associated HARQ-ACK covers the RTD of service link, another Koffset is needed to cover the RTD of the feeder link for MAC-CE application.

Hence, our view is to stick with study item phase agreement with a Koffset the same or a different value as the Koffset in Proposal 1. |
| Lenovo/MM | Agree with QC. |
| CMCC | Support Option 2, however, the statement of timing relationship enhancement for MAC CE in TR 38.821 seems incorrect, so it is suggested to amend it as following (In fact, it is same to R15/R16 specification).**MAC CE action timing**: When the HARQ-ACK corresponding to a PDSCH carrying a MAC-CE command is transmitted in UL 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 DL slot $n+X∙N\_{slot}^{subframe,μ}$, where $N\_{slot}^{subframe,μ}$ denotes the number of slots per subframe for subcarrier spacing configuration $μ$.* Note that for other timing relationship enhancement for NTN (e.g., DCI scheduled PUSCH, RAR grant scheduled PUSCH, etc.), it is using DL timing $n$ to determine the UL timing $n+K\_{offset}+K$. As shown in Figure (a), when a UE receives DCI in DL slot $n$, it knows to transmit PUSCH in UL slot $n+K\_{offset}+K\_{2}$.
* Nevertheless, for MAC CE, it is using UL timing $n$ (when sending HARQ-ACK) to determine the DL timing $n+K$ (when MAC CE command received in DL is active). As shown in Figure (b), when a UE transmits HARQ-ACK in UL slot $n$, it knows that the corresponding MAC CE command is active after its DL slot $n+K$.

1. Transmission timing for PUSCH scheduled by DCI

1. MAC CE action timing
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## 3.3 Updated proposal based on company views

To be added…

# 4 Issue #4: Additional timing relationships that may or may not need Koffset

## 4.1 Background

There are several proposals on additional timing relationships that may need to be enhanced. They may or may not require the use of $K\_{offset}$.

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| **Tdoc** | **Source** | **Proposals** |
| [**R1-2005873**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005873.zip) | Intel Corporation | **Proposal 3**: * Support 2-step RACH procedure for NTN
	+ Consider enhancements for 2-step RACH timing relationships in NTN including timing of PUSCH scheduled by fallback random-access response (RAR) and timing of HARQ-ACK feedback for MsgB
 |
| [**R1-2006358**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006358.zip) | ETRI | **Proposal 2**: When configuring the RACH occasion for NTN, it may be necessary to change the time interval of PRACH transmission due to the request of higher layers. |
| [**R1-2006640**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006640.zip) | Asia Pacific Telecom co. Ltd | **Proposal 3** Timing relationship enhancement on configured grant PUSCH transmission shall be FFS. |
| [**R1-2006855**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006855.zip) | 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**: In NTN, UE starts sr-ProhibitTimer $K\_{offset}$ slots after the UE transmits SR on one valid PUCCH resource.  |

## 4.2 Company views

The additional timing relationships from the proposals in the previous section include

* 2-step RACH timing relationships including timing of PUSCH scheduled by fallback random-access response (RAR) and timing of HARQ-ACK feedback for MsgB.
* Time interval of RACH occasions
* Configured grant PUSCH timing relationship
* DCI 2\_0 scheduled SFI timing relationship
* Start of sr-ProhibitTimer

Regarding the start of sr-ProhibitTimer, it is a topic belonging to RAN2 expertise area. For the other ones, they can be discussed in RAN1. That said, as these proposals appear to be brought up for the first time, companies may need a bit more time to check them.

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

**Initial proposal 4-1 (Moderator):**

FFS additional timing relationships including

* 2-step RACH timing relationship including timing of PUSCH scheduled by fallback random-access response (RAR) and timing of HARQ-ACK feedback for MsgB.
* Time interval of RACH occasions
* Configured grant PUSCH timing relationship
* DCI 2\_0 scheduled SFI timing relationship

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| Company | Comments |
| Ericsson | * 2-step RACH timing relationship
	+ PUSCH scheduled by fallback RAR: It appears there is no difference compared to normal RAR scheduled PUSCH, for which the need of $K\_{offset}$ has been identified.
	+ HARQ-ACK feedback for MsgB: It appears reasonable to discuss this.
* Time interval of RACH occasions: It is not clear what the proponent is proposing here.
* Configured grant PUSCH timing relationship: It would be helpful if the proponent can be more concrete about what timing relationship in configured grant PUSCH needs to be discussed.
* DCI 2\_0 scheduled SFI timing relationship: It appears reasonable to discuss if $K\_{offset}$ should be introduced.
 |
| MediaTek | * 2-step RACH procedure could first be discussed in RAN2 to identify if there is any need for enhancements and potential impact on RAN1.
 |
| Lenovo/MM | Support to further discuss these timing relationships. |
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## 4.3 Updated proposal based on company views

To be added…

# 5 Issue #5: TA focused proposals

## 5.1 Background

There are a number of proposals on timing advance submitted to A.I. 8.4.1, as summarized in the table below.

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| **Tdoc** | **Source** | **Proposals** |
| [**R1-2005265**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005265.zip) | Huawei, HiSilicon | **Proposal 1**: RAN1 strives for a unified signaling framework to support “full TA” and “partial TA”. |
| [**R1-2005495**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005495.zip) | MediaTek Inc. | **Proposal 1**: Idle UE reports its autonomously determined TA in spare bits of Msg 3 during random access procedure.**Proposal 2**: Connected UE reports its autonomously determined TA to the gNB. **Proposal 4**: Study options for the triggering of the TA report by the connected UE: * Network initiated report options
* UE initiated report options
 |
| [**R1-2005573**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005573.zip) | Sony | **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.  |
| [**R1-2005706**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005706.zip) | CATT | **Proposal 1**: Compensation of UE-specific differential TA only should be used. |
| [**R1-2005963**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005963.zip) | ZTE | **Proposal 1**: Aligned DL-UL frame boundary at scheduler (i.e., gNB side) side should be the baseline for timing relationship enhancement. |
| [**R1-2006210**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006210.zip) | CMCC | **Proposal 1**: W.r.t. timing relationship in NTN, Solution 1 (i.e., UE applies a large TA to guarantee that gNB’s DL and UL frame timing keep aligned) is preferred.**Proposal 2**: It is suggested to define UE’s timing relationship according gNB’s ones, i.e.,* The DL timing boundary of slot n at UE side is determined as the receiving timing of DL signal transmit, which is transmit by network at slot n at gNB side;
* The UL timing boundary of slot n at UE side is determined as the transmission timing of UL signal, which is received by network at slot n at gNB side.
 |
| [**R1-2006358**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006358.zip) | ETRI | **Proposal 1**: The slot interval in which the value indicated by the timing advance command is applied to the UL transmission timing may be changed according to the definition of $N\_{TA}$. If the slot interval in which the value indicated by the timing advance command is applied increases, an analysis of the accuracy of the TA value at the time of application is required. |
| [**R1-2006804**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006804.zip) | Qualcomm Incorporated | **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.
 |

## 5.2 Company views

These TA proposals submitted to A.I. 8.4.1 are closely related to the topics on UL time and frequency synchronization in A.I. 8.4.2. It appears more sensible to handle the discussion under A.I. 8.4.2. Alternatively, they can be treated under A.I. 8.4.1 once sufficient progress has been made in A.I. 8.4.2.

**Initial proposal 5-1 (Moderator):**

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.

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| Company | Comments |
| Ericsson | Ok with proposal 5-1. |
| MediaTek | Support proposal 5-1 |
| QC | OK with proposal 5-1. |
| Lenovo/MM | Support proposal 5-1 |
| CMCC | Support proposal 5-1 |
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## 5.3 Updated proposal based on company views

To be added…

# 6 Issue #6: Extension of value ranges of K1 and K2

## 6.1 Background

There are some proposals on extension of value ranges of K1 and K2.

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| **Tdoc** | **Source** | **Proposals** |
| [**R1-2005833**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005833.zip) | Lenovo, Motorola Mobility | **Proposal 2**: Support extending the range of K1 value. |
| [**R1-2005963**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005963.zip) | ZTE | **Proposal 3**: The impact of UE specific TA on scheduling offset can be handled via extension of existing offset (i.e., k, K1, K2). |
| [**R1-2006210**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006210.zip) | CMCC | **Proposal 7**: Extending the value range of dl-DataToUL-ACK field in PUCCH-Config IE to larger than 15, e.g., 31. |
| [**R1-2006855**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006855.zip) | CAICT | **Proposal 4**: To enhance the DL-UL timing indication with more contiguous DL slots in TDD system.  |

## 6.2 Company views

The motivation of extending value ranges of K1 and K2 seems to be mainly about TDD scenario. According to the WID [2], FDD is assumed for NTN specification work. That said, the WID also mentions “implicit compatibility” to support HAPS and A2G. So, a more general question is how to treat TDD originated proposals during Rel-17 NTN WI.

* *FDD is assumed for core specification work for NR-NTN.*
	+ *NOTE: This does not imply that TDD cannot be used for relevant scenarios e.g. HAPS, ATG*

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

**Initial proposal 6-1 (Moderator):**

Discuss how to treat TDD originated proposals during Rel-17 NTN WI, such as extending value ranges of K1 and K2.

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| Company | Comments |
| Ericsson | Perhaps some clarification on the WI scope at RAN plenary would be beneficial. |
| MediaTek | For ATG NR TDD, need for extending K1 value could be discussed |
| QC | Not sure if the ranges of K1 and K2 are the only issue for ATG TDD. |
| Lenovo/MM | The motivation of extending K1/K2 is not only for TDD. It is also applied for FDD case. |
| CMCC | In our understanding, extending K1 value range is not a specific requirement of ATG, actually it is beneficial for both LEO and ATG scenario.For example in LEO scenario, enlarge K1/K2 value range is beneficial to enable flexibly changing of timing relationship via DCI, which may reduce RRC signaling overhead for frequently updating $K\_{offset}$ to fit rapidly changed RTT.In ATG scenario, enlarge K1 value range is beneficial to reduce GP overhead. So, it is suggested to extend the range of K1 value. |
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## 6.3 Updated proposal based on company views

To be added…

# 7 Issue #7: Others

## 7.1 Background

There is a proposal suggesting RAN1 to discuss a basic set of assumptions that have design impact. It was submitted to A.I. 8.4.1 due to lack of RAN1 agenda on the topic.

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| **Tdoc** | **Source** | **Proposals** |
| [**R1-2006464**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006464.zip) | Ericsson | **Proposal 1** RAN1 to discuss a basic set of assumptions that have design impact in Rel-17.**Proposal 2** An agreement on an assumption does not mean the agreement needs to be captured in the specification. Rather, an agreement on an assumption serves as a reference for discussing aspects that could lead to specification impact. |

It is noticed that the following contribution submitted to A.I. 8.4 also discusses design assumptions for NTN.

* R1-2006676, THALES, NR NTN Reference scenarios definition for Rel-17 normative phase

## 7.2 Company views

Some common assumptions may be helpful for facilitating progress in Rel-17 NR NTN WI. Otherwise, different companies might have different assumptions in mind when making proposals.

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

**Initial proposal 7-1 (Moderator):**

Discuss the necessity on a basic set of assumptions that may have design impact in Rel-17.

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| Company | Comments |
| Ericsson | It is good to clarify common assumptions.  |
| CMCC | It is good to clarify the common assumption, ATG scenario needs to be considered. |
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## 7.3 Updated proposal based on company views

To be added…

# References

1. TR 38.821, Solutions for NR to support non-terrestrial networks.
2. RP-201256, “Solutions for NR to support non-terrestrial networks (NTN),” 3GPP TSG RAN #88e, June 2020.
3. R1-2005265, Discussion on timing relationship enhancements for NTN, Huawei, HiSilicon
4. R1-2005495, Timing relationship enhancements for NR-NTN, MediaTek Inc.
5. R1-2005548, NR-NTN: Timing Relationship Enhancements, Fraunhofer IIS, Fraunhofer HHI
6. R1-2005573, Calculation of timing relationship offsets, Sony
7. R1-2005706, Timing relationship enhancement for NTN, CATT
8. R1-2005833, Discussion on NTN timing relationship, Lenovo, Motorola Mobility
9. R1-2005873, On timing relationship enhancements for NTN, Intel Corporation
10. R1-2005963, Discussion on timing relationship for NTN, ZTE
11. R1-2006029, discusson on timing relationship enhancement, OPPO
12. R1-2006144, On Timing relationship enhancements, Samsung
13. R1-2006210, Discussion on timing relationship enhancements for NTN, CMCC
14. R1-2006325, Timing relationship enhancement for NTN, Panasonic Corporation
15. R1-2006358, Discussion on timing relationships for NTN, ETRI
16. R1-2006378, Discussions on timing relationship enhancements in NTN, LG Electronics
17. R1-2006421, DL-UL timing relationship for NTN operation, Nokia, Nokia Shanghai Bell
18. R1-2006464, On basic assumptions and timing relationship enhancements for NTN, Ericsson
19. R1-2006519, On Timing Relationship Enhancement in NTN, Apple
20. R1-2006589, Discussion on the timing relationship for NTN, Beijing Xiaomi Mobile Software
21. R1-2006640, Discussion on timing relationship enhancements for NTN, Asia Pacific Telecom co. Ltd
22. R1-2006804, Enhancements on Timing Relationship for NTN, Qualcomm Incorporated
23. R1-2006855, Timing relationship enhancements to support NTN , CAICT

# Appendix: Summary of proposals

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| **Tdoc** | **Source** | **Proposals** |
| [**R1-2005265**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005265.zip) | Huawei, HiSilicon | **Proposal 1**: RAN1 strives for a unified signaling framework to support “full TA” and “partial TA”.**Proposal 2**: Derive the initial cell-specific Koffset from broadcast information, e.g., ra-ResponseWindow and an offset for the start of the ra-ResponseWindow.**Proposal 3**: To reduce the scheduling delay, support updating Koffset from cell-specific to beam-specific. |
| [**R1-2005495**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005495.zip) | MediaTek Inc. | **Proposal 1**: For UL transmission timing, introduce an offset Koffset for NR NTN.* For UL HARQ-ACK on PUCCH, where HARQ ACK on PUCCH is transmitted on slot n + K1 + Koffset when a scheduling DCI is received in slot n.
* For UL transmission on PUSCH, where PUSCH is transmitted on slot $\left⌊n∙2^{μ\_{PUSCH}-μ\_{PDCCH}}\right⌋+K\_{2}+K\_{offset}$ when a scheduling DCI is received in slot n.
* For CSI transmission on PUSCH, where CSI on PUSCH is transmitted on slot n +K+Koffset, when the DCI with CSI request is received in slot n and K is selected by the DCI.
* For a CSI report in uplink slot n’, the CSI reference resource is given in downlink slot n-nCSI\_ref$-K\_{offset}$, where  and nCSI\_ref is as defined in 38.214.
* With reference to slots for a PUSCH transmission scheduled by a RAR UL grant, if a UE receives a PDSCH with a RAR message ending in slot $n$ for a corresponding PRACH transmission from the UE, the UE transmits the PUSCH in slot $n + K\_{2} +Δ+K\_{offset}$.
* 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}$$n+3N\_{slot}^{subframe,µ}+K\_{offset}$ (X can be determined when specifications are developed).
* If a UE receives a DCI triggering aperiodic SRS in slot n, the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in slot $⌊n∙2^{\frac{μ\_{SRS}}{μ\_{PDCCH}}}⌋+k+K\_{offset}$.
* Koffset is per beam or per-cell

**Proposal 1**: Idle UE reports its autonomously determined TA in spare bits of Msg 3 during random access procedure.**Proposal 2**: Connected UE reports its autonomously determined TA to the gNB. **Proposal 3**: Beam-specific Koffset based on Maximum RTT for scheduling of Message 3 is broadcast on SIB **Proposal 4**: Study options for the triggering of the TA report by the connected UE: * Network initiated report options
* UE initiated report options
 |
| [**R1-2005548**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005548.zip) | Fraunhofer IIS, Fraunhofer HHI | **Proposal 1**: RAN1 to check if the given list for impacted clauses is complete and needs to be captured. **Proposal 2**: RAN1 to decide on the unit of the values of $K\_{offset}$**.**.**Proposal 3**: Adopt $K\_{offset}$ according to the UE specific TA.**Proposal 4**: Broadcast the value of $K\_{offset}$ based on (2) as part of SIB. |
| [**R1-2005573**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005573.zip) | Sony | **Proposal 1**: When the common TA is configured by gNB, the Koffset values should be calculated 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.  |
| [**R1-2005706**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005706.zip) | CATT | **Proposal 1**: Compensation of UE-specific differential TA only should be used.**Proposal 2**: The values of $K\_{offset}$ should be notified within per-beam/per-cell based on the SIB. |
| [**R1-2005833**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005833.zip) | Lenovo, Motorola Mobility | **Proposal 1**: Support per beam indication of Koffset.**Proposal 2**: Support extending the range of K1 value.**Proposal 3**: At least broadcast signaling is supported. Dedicated higher layer signaling can be FFS.**Proposal 4**: Study enhancement on slot format due to large propagation delay and transparent payload. |
| [**R1-2005873**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005873.zip) | Intel Corporation | **Proposal 1**: * Support additional slot offset Koffset for the following cases
	+ For the transmission timing of DCI scheduled PUSCH (including CSI on PUSCH)
	+ For the transmission timing of RAR grant scheduled PUSCH
	+ For the transmission timing of HARQ-ACK on PUCCH
	+ For the CSI reference resource timing
	+ For the transmission timing of aperiodic SRS
* The values of Koffset are broadcasted by the gNB per beam

**Proposal 2**: * 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)

**Proposal 3**: * Support 2-step RACH procedure for NTN
	+ Consider enhancements for 2-step RACH timing relationships in NTN including timing of PUSCH scheduled by fallback random-access response (RAR) and timing of HARQ-ACK feedback for MsgB
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| [**R1-2005963**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2005963.zip) | ZTE | **Proposal 1**: Aligned DL-UL frame boundary at scheduler (i.e., gNB side) side should be the baseline for timing relationship enhancement.**Proposal 2**: The Koffset for all UEs should be derived from corresponding common TA value.**Proposal 3**: The impact of UE specific TA on scheduling offset can be handled via extension of existing offset (i.e., k, K1, K2).**Proposal 4**: In case of UE dominated synchronization approach, the reported TA value from UE side should be considered for the configuration of UE specific offset (i.e., k, K1, K2).**Proposal 5**: For Msg-3 transmission, the existing offset (K2) should be configured to cover the maximum UE specific TA value. **Proposal 6**: In case of indication on the offset, i.e., common offset and UE specific offset, proper setting of the unit should be considered to support all scenarios with lower overhead. **Proposal 7**: For the MAC CE action timing, the existing value of X , i.e., X = 3, can be reused in NTN. |
| [**R1-2006029**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006029.zip) | OPPO | **Proposal 1**: Cell-specific, UE-specific are group-UE specific timing offset configuration can be considered. **Proposal 2**: Koffset updating can consider UE triggered and gNB controlled manners.  |
| [**R1-2006144**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006144.zip) | 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. |
| [**R1-2006210**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006210.zip) | CMCC | **Proposal 1**: W.r.t. timing relationship in NTN, Solution 1 (i.e., UE applies a large TA to guarantee that gNB’s DL and UL frame timing keep aligned) is preferred.**Proposal 2**: It is suggested to define UE’s timing relationship according gNB’s ones, i.e.,* The DL timing boundary of slot n at UE side is determined as the receiving timing of DL signal transmit, which is transmit by network at slot n at gNB side;
* The UL timing boundary of slot n at UE side is determined as the transmission timing of UL signal, which is received by network at slot n at gNB side.

**Proposal 3**: Conform the following timing relations enhancement as discussed in TR 38.821 at NTN work item,* Transmission timing for PUSCH scheduled by DCI
* Transmission timing for CSI on PUSCH
* Transmission timing for PUSCH scheduled by RAR grant
* Transmission timing for HARQ-ACK on PUCCH
* CSI reference resource timing
* Aperiodic SRS transmission timing

**Proposal 4**: Further discussion on the timing relationships enhancement for MAC CE action timing in NTN.**Proposal 5**: Default timing offset ($K\_{offset}^{default}$), which is determined by common TA and maximum possible TA adjustment range indicated by RAN, can be used for random access procedure and/or RRC connection re-establish procedure.**Proposal 6**: After RRC connection setup, UE specified timing offset ($K\_{offset}$) may be signaled by higher layers.**Proposal 7**: Extending the value range of dl-DataToUL-ACK field in PUCCH-Config IE to larger than 15, e.g., 31. |
| [**R1-2006325**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006325.zip) | Panasonic Corporation | **Proposal 1**: In addition to cell/beam specific Koffset for timing relationship on DCI scheduled PUSCH, HARQ-ACK on PUCCH and aperiodic SRS, UE specific control, Koffset,UE, should be introduced. When the network has the UE location or UE autonomous TA information, the network can use it.**Proposal 2**: To clarify the MAC CE reflection timing of DL status is after the timing gNB receives HARQ-ACK.**Proposal 3**: The same offset value as UL transmission timing, Koffset and Koffset,UE, is applied to the timing relationship for the CSI reference resource. |
| [**R1-2006358**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006358.zip) | ETRI | **Proposal 1**: The slot interval in which the value indicated by the timing advance command is applied to the UL transmission timing may be changed according to the definition of $N\_{TA}$. If the slot interval in which the value indicated by the timing advance command is applied increases, an analysis of the accuracy of the TA value at the time of application is required.**Proposal 2**: When configuring the RACH occasion for NTN, it may be necessary to change the time interval of PRACH transmission due to the request of higher layers.**Proposal 3**: $K\_{offset}$ may be configured through an expansion of the resource indicator field of NR or a new parameter field. If it is configured with a new parameter field, it may be configured as a table similar to the resource indicator field of NR. |
| [**R1-2006378**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006378.zip) | LG Electronics | **Proposal 1**: K\_offset per beam is independently configured by high-layer.**Proposal 2**: Discuss whether and how to updated K\_offset value.  |
| [**R1-2006421**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006421.zip) | Nokia, Nokia Shanghai Bell | **Proposal 1**: The formulas for UL-DL timing relationships should include a single offset $K\_{NTN}$ to account for the propagation delay.**Proposal 2**:The offset factor, $K\_{NTN}$, should be applicable for all UL-DL timing relationships.**Proposal 3**: $K\_{NTN}$must be available before the UE random access, for example, indicated by broadcast messages by the gNB. **Proposal 4**: The UL-DL timing relationships adjustments should be dynamic to follow the propagation variation over time. **Proposal 5**: RAN1 to discuss if UE-specific values for $K\_{NTN}$ can be specified in complement to the cell base  |
| [**R1-2006464**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006464.zip) | Ericsson | **Proposal 1** RAN1 to discuss a basic set of assumptions that have design impact in Rel-17.**Proposal 2** An agreement on an assumption does not mean the agreement needs to be captured in the specification. Rather, an agreement on an assumption serves as a reference for discussing aspects that could lead to specification impact.**Proposal 3** The unit of $K\_{offset}$ is specified in terms of millisecond. For each identified timing relationship that needs to be modified for NTN, the value of $K\_{offset}$ is translated into a number of slots by multiplying the value with $2^{μ}$, where is the corresponding numerology of the slot numbering in the identified timing relationship.**Proposal 4** The value range of $K\_{offset}$ is 1, 2, …, 600 ms.**Proposal 5** The value of $K\_{offset}$ is signaled at least in SIB1 and is cell specific.**Proposal 6** The value of $K\_{offset}$ can be reconfigured for each UE after RRC connection setup to be UE specific for unicast scheduling.**Proposal 7** NTN UE can report its capability in terms of MAC CE action timing application delay.**Proposal 8** RAN1 should determine suitable MAC CE activation times for e.g. TCI states and spatial relations to support beam change.**Proposal 9** RAN1 should determine if TCI and spatial relations activation at beam change in Earth-moving beam scenario should be managed by UE specific MAC CE signaling, by groupcast or by broadcast signaling. |
| [**R1-2006519**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006519.zip) | Apple | **Proposal 1**: The UE-specific $K\_{offset}$ is equal to full TA, divided by slot duration. **Proposal 2**: For MAC CE action timing, the value X is smaller than 3.  |
| [**R1-2006589**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006589.zip) | Beijing Xiaomi Mobile Software | **Proposal 1**: If UE-specific differential TA compensation is applied at UE side, the Koffset could be configured as the max differential RTT offset.**Proposal 2**: If full TA compensation is applied at UE side, the Koffset could be configured as the max RTT.**Proposal 3**: The Koffset can be transmitted in the SIB.**Proposal 4**: The Koffset is configured with a unit of millisecond. |
| [**R1-2006640**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006640.zip) | Asia Pacific Telecom co. Ltd | **Proposal 1** For Earth moving cells, set K\_offset as a fixed value per cell.**Proposal 2** For Earth fixed cells, signalling on K\_offset update shall be FFS.**Proposal 3** Timing relationship enhancement on configured grant PUSCH transmission shall be FFS. |
| [**R1-2006804**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006804.zip) | Qualcomm Incorporated | **Proposal 1**: * The value of timing delay, *K*offset, is broadcasted per cell or per beam and is applied as in the following timing relationships:
	+ For UL HARQ-ACK on PUCCH in response to a scheduling DCI received in slot n , UE transmits the HARQ ACK on PUCCH on slot n + K1 + Koffset .
	+ When a scheduling DCI of a PUSCH is received in slot n, UE transmits the PUSCH on slot $\left⌊n∙2^{μ\_{PUSCH}-μ\_{PDCCH}}\right⌋+K\_{2}+K\_{offset}$.
	+ When a DCI with CSI request is received in slot n and K is selected by the DCI, UE transmits CSI on PUSCH on slot n +K+Koffset, where K is indicated by the DCI.
	+ For a CSI report in uplink slot n’, the CSI reference resource is given in downlink slot n-nCSI\_ref$-K\_{offset}$, where  and nCSI\_ref is as defined in 38.214.
	+ With reference to slots for a PUSCH transmission scheduled by a RAR UL grant, if a UE receives a PDSCH with a RAR message ending in slot $n$ for a corresponding PRACH transmission from the UE, the UE transmits the PUSCH in slot $n + K\_{2} +Δ+K\_{offset}$.
	+ 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}$$n+3N\_{slot}^{subframe,µ}+K\_{offset}$ (the value of X is FFS).
	+ If a UE receives a DCI triggering aperiodic SRS in slot n, the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in slot $⌊n∙2^{\frac{μ\_{SRS}}{μ\_{PDCCH}}}⌋+k+K\_{offset}$.
* Additional configuration and mechanisms can be considered to overwrite the value for one or more of the above relationships.

**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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| [**R1-2006855**](http://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_102-e/Docs/R1-2006855.zip) | 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**: In NTN, UE starts sr-ProhibitTimer $K\_{offset}$ slots after the UE transmits SR on one valid PUCCH resource.**Proposal 3**: To consider the value of $K\_{offset}$ be UE-specific and corresponds to the value of timing advance to modify the relevant timing relationships between each kind of DL-UL timing interaction.**Proposal 4**: To enhance the DL-UL timing indication with more contiguous DL slots in TDD system.  |