e3GPP RAN WG2 Meeting #112e R2-200xxxx

November 2nd – 13th, 2020

Agenda Item: X.X.X.X

Source: InterDigital (email discussion Rapporteur)

Title: [DRAFT] [Post111-e][908][NTN] RACH and HARQ feedback aspects

Document for: Discussion, Decision

# Introduction

This discussion document is intended to enable continuation of user plane discussions from RAN2#111e, specifically relating to RACH and a subset of HARQ feedback-related aspects:

* [Post111-e][908][NTN] RACH and HARQ feedback aspects (Interdigital)

Scope: Continue the discussion on RACH aspects as well as on p1, p10, p11 in [R2-2008214](file:///C%3A%5CData%5C3GPP%5CRAN2%5CInbox%5CR2-2008214.zip)

Intended outcome: email discussion summary

 Deadline: Long

Referring to the Rel-17 NTN WID [1], RACH scope continues to address the following aspects:

* *Random access:*
	+ *Definition of an offset for the start of the ra-ResponseWindow for NTN.*
	+ *Introduction of an offset for the start of the ra-ContentionResolutionTimer to resolve Random access contention*
	+ *Solutions for resolving preamble ambiguity and extension of RAR window.*
	+ *Adaptation for Msg-3 scheduling*
		- *Only for the case with pre-compensation of timing and frequency offset at UE side)*

And the following HARQ-related proposals from the previous user plane offline email discussion summary [2]:

*Proposal 1: Agreement 4 is clarified as follows:*

*From a RAN2 perspective, uplink HARQ feedback for downlink transmission at UE receiver and HARQ uplink retransmission at UE transmitter can be enabled/disabled in Rel-17 NTN, but HARQ processes remain configured. The criteria and decision to enable/disable HARQ feedback is under network control and is signalled to the UE via RRC in a semi-static manner.*

*Proposal 10: If HARQ feedback is enabled, an offset is applied to the start of drx-HARQ-RTT-TimerDL and drx-HARQ-RTT-TimerUL for both LEO and GEO scenarios.*

*Proposal 11: If HARQ feedback is disabled, drx-HARQ-RTT-TimerDL and drx-HARQ-RTT-TimerUL are not started for both LEO and GEO scenarios.*

Please note the final deadline for company feedback has been provided by the session and RAN2 chair. An interim deadline is further included to allow for company feedback on discussion summary and draft proposals:

* Initial deadline for companies' feedback to discussion document: **Friday October 9th 23:59 EDT**
* Final deadline company input to summary and draft proposals: **Thursday October 15th 23:59 EDT**

# Continuation of RACH discussion

## Offset and Extentions

### Ra-ResponseWindow and ra-ContentionResolutionTimer offset value

From RAN2#111e, the following agreements were made concerning the offset of the *ra-ResponseWindow* and the *ra-ContentionResolutionTimer* [3]:

Agreements via email - from offline 107

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.

Introduction of an offset to the above timers was intended to accommodate the large propagation delay resulting from extension of NR to a non-terrestrial environment. Additional discussion focused on the value of delay compensation, where solution options can be generally categorized as compensating either:

* **Common Delay:** A delay value corresponding to a common reference point, experienced by all UEs served within the cell/beam.
* **UE-specific delay:** A delay value corresponding to the total delay between the UE and the gNB/reference point, where this value is specific to each UE within the cell/beam.

From the Phase 2 summary of offline [AT111][107] [2], although a majority of companies (17/23) responded that UE-specific delay compensation is always needed regardless of LEO or GEO deployment scenario, this discussion was ultimately inconclusive.

RAN1 is also discussing delay compensation aspects specifically in relation to time/frequency precompensation, where discussion summary from RAN1#102e can be found in [4]. This has led to the following RAN1 agreements [5]:

*Agreement:*

* *In Rel-17 NR NTN, at least support UE which can derive based on its GNSS implementation one or more of:*
	+ *its position*
	+ *a reference time and frequency*
* *And, based on one or more of these elements together with additional information (e.g., serving satellite ephemeris or timestamp) signalled by the network, can compute timing and frequency, and apply timing advance and frequency adjustment at least for UE in RRC idle/inactive mode.*
	+ *FFS: Details on additional information signalled from network*

*Agreement:*

*In case of GNSS-assisted TA acquisition in RRC idle/inactive mode, the UE calculates its TA based on the following potential contributions:*

* *The User specific TA which is estimated by the UE:*
	+ *Option 1: The User specific TA is estimated by the UE based on its GNSS acquired position together with the serving satellite ephemeris indicated by the network:*
		- *FFS: Details on serving satellite ephemeris indication*
	+ *Option 2: The User specific TA  is estimated by the UE based on the GNSS acquired reference time at UE together with reference time as indicated by the networ*k
* *The Common TA if indicated by the network:*
	+ *FFS: The need and details of Common TA indication*

From above agreements, it seems that although the method of calculation is FFS (e.g. timestamp-based solution or UE location-based solution), UE-specific delay for purposes of UE time/frequency pre-compensation\* is supported. This conclusions appears to be in-line with RAN2 majority understanding from [2] and [6].

*\*Note: This does not preclude further enhancement for UEs not capable of UE-specific precompensation (i.e. with only some form of common delay compensation) should RAN1 determine this solution also be necessary.*

**Question 2.1: Do you agree that based on above RAN1 agreements and previous RAN2 discussion [2], RAN2 to assume UE can *at least* derive UE-specific delay based on its GNSS implementation in LEO/GEO deployments (with method FFS)?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | UE can derive UE-specific delay based on its GNSS implementation in LEO/GEO deployments |
| APT | Agree  |  |
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Should companies conclude that at least UE-specific delay is known at the UE and can used for time/frequency synchronization, a baseline definition of timer offset values may be determined.

**Question 2.2: If “Agree” to Question 2.1, do you agree that *ra-ContentioResolutionTimer* offset is defined using UE-specific delay as baseline in LEO/GEO?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | *ra-ContentioResolutionTimer* offset should be defined using UE-specific delay as baseline in LEO/GEO |
| APT | Agree |  |
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As noted in previous offline discussion [6] the start of the *ra-ResponseWindow* is captured by RAN1 in TS 38.213. However, referring to WID, definition of the offset is under RAN2 scope:

* *Definition of an offset for the start of the ra-ResponseWindow for NTN.*

**Question 2.3: If “Agree” to Question 2.1, do you agree that *ra-ResponseWindow* offset is defined using UE-specific delay as baseline in LEO/GEO? (Note: modification to start of *ra-ResponseWindow* to be captured by RAN1 in TS 38.213)**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | ra-ResponseWindow offset should be defined using UE-specific delay as baseline in LEO/GEO. Same is true for msgB-ResponseWindow. |
| APT | Agree |  |
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**Question 2.4: If “Agree” to Question 2.3, should and LS be sent to RAN1?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | An LS should be sent to RAN1 |
| APT | Agree  | LS to RAN1 is needed because R1-1909479 shows RAN1’s consensus that enhancement for the RAR window/RA-RNTI related issues should be up to RAN2 discussion. It is better to clarify that the start of the RAR window shall be captured by RAN1.  |
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### Extention of the ra-ResponseWindow

In addition to introduction of an offset to the *ra-ResponseWindow*, extension to cover the maximum differential delay of an NTN cell/beam was discussed. In NTN GEO, two times the maximum differential delay (20.6 ms) exceeds the current maximum monitoring duration in a licensed spectrum for the *ra-ResponseWindow* (10 ms). Therefore, for UEs at cell edge, if the *ra-ResponseWindow* is started in the first PDCCH monitoring occasion after 2 times the minimum delay, the monitoring duration may expire before reception of the RA response.

From [AT111][107] Phase 1 offline summary [6], a large majority of companies (19/26) responded that an extension to the *ra-ReponseWindow* is not needed if an appropriate offset is applied, with a further (6/26) companies clarifying that if UE-specific delay (from gNB to UE) is compensated then an extension is not necessary. Therefore, if companies agree to Question 2.3 (the baseline offset defintition to the *ra-ResponseWindow* is via a UE-specific delay), from past discussion the following may also be agreeable:

**Question 2.5: If the start of the *ra-ResponseWindow* is compensated by a UE-specific delay-based offset, do you agree an extension of the *ra-ResponseWindow* is not needed in LEO/GEO?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | Extension of the *ra-ResponseWindow* is not needed in LEO/GEO |
| APT  | Agree  | No need for this RAR window extension if each UE can calculate proper UE-specific offset for the start of the RAR window.  |
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### Preamble Ambiguity

Given the large maximum differential delay possible in NTN, it is noted in section 7.2.1.1.1.2 of TR 38.821 [7] that certain RACH occasion periodicities configurable in Rel-16 NR may lead to overlaps in preamble receiving windows between successive RACH occasions. gNB may not know which RO the preamble is associated with in the overlap period, thus may not be able to accurately estimate the appropriate timing advance.

In [AT111][107] Phase 1 offline [6], a number of potential solutions to address this issue where examined. However, based on responses a majority of companies (14/26) commented that should UE-specific delay be compensated, RACH preamble ambiguity may not be an issue.

**Question 2.6: If UE-specific RTD is compensated, is preamble ambiguity still an issue in LEO/GEO? If ‘Yes’ please describe the remaining issue(s) to be addressed in the ‘Additional Comments’ section.**

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| **Company** | **Yes/No** | **Additional comments** |
| MediaTek | No | With UE-specific RTD precompensation, preamble ambiguity will not be an issue. |
| APT  | No  |   |
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### Method of offset calculation

Referring to Section 2.1.1, RAN1 has agreed to further evaluate the following options regarding calculation of UE-specific delay: (Note Option 1 may additionally have a portion of common delay, e.g. feeder-link delay, to obtain the full RTD from the UE to land-based gNB. Companies are encourage to refer to [4] for detailed solution description)*:*

* *Option 1: The User specific TA is estimated by the UE based on its GNSS acquired position together with the serving satellite ephemeris indicated by the network:*
	+ *FFS: Details on serving satellite ephemeris indication*
* *Option 2: The User specific TA  is estimated by the UE based on the GNSS acquired reference time at UE together with reference time as indicated by the network*

A similar discussion occured in RAN2#111e, where solutions were discussed and described as follows [6]:

* *Option 3: UE-specific offset calculated by UE based on UE-satellite location;*

*...*

* *Option 5: UE-specific offset calculated by UE based on UTC time (via IE in SIB9);*

The outcome of this discussion [6] resulted in (20/27) companies supporting Option 3 (i.e. RAN1 Option1) and (3/27) companies supporting option 5 (i.e. RAN1 option 2).

As the method of TA calculation/compensation may also impact RAN2 signalling and procedures (e.g. SIB acquisition), companies are invited to indicate a preference on RAN1 options *from a RAN2 perspective*, as well as any potential impacts to RAN2 work resulting from the adoption of either method, if identified.

**Question 2.7: What is the preferred method of UE-specific delay timing pre-compensation *from a RAN2 perspective*? Companies are invited to list potential impacts on RAN2 work associated with each option (if identified) in the “Additional Comments” section.**

* **Option 1: The User specific TA is estimated by the UE based on its GNSS acquired position together with the serving satellite ephemeris indicated by the network**
* **Option 2: The User specific TA  is estimated by the UE based on the GNSS acquired reference time at UE together with reference time as indicated by the network**

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| **Company** | **Preferred Option (1 or 2)** | **Additional comments** |
| MediaTek | Option 1 | The User specific TA should estimated by the UE based on its GNSS acquired position together with the serving satellite’s ephemeris information indicated by the network.Knowing the satellite position and the UE position, the UE can calculate the propagation distance between satellite and UE and then calculate the TA. Hence, the knowledge of time (Option 2) is not needed. Option 1 is simpler as it does not require UE to use GNSS capability as often to acquire its position. On the other hand, Option 2 requires UE to use its GNSS capability very often to maintain its time reference accurately. |
| APT  | Option 1  | Option 1 is better for LEO-based NTN. In this case, satellite ephemeris is crucial for UL frequency synchronization and mobility enhancement.    Option 2 is better for NTN ingeneral, including GEO, Air-to-Ground (ATG), and Unmanned Aircraft Systems (UAS). In these cases, whether providing satellite ephemeris does not matter.  |
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## Msg3 scheduling adaptation

Based on the outcome of the previous Phase 1 offline discussion [AT111][107] [6], a large majority of companies (23/26), supported the following option to address Msg3 scheduling adaptation for UE with UE-specific pre-compensation:

*Option 1: Network scheduling/implementation (i.e. no modification necessary)*

Leading to the following proposal for online discussion:

*From RAN2 perspective, for UE with UE-specific pre-compensation as a baseline it is up to gNB implementation to ensure a sufficient processing time on UE side for the Msg3 transmission*

However during RAN2#111e online discussion, concerns were raised about the terminology “UE processing time”. Email discussion rapporteur suggests a compromise proposal by removing the word “processing”, i.e.:

*From RAN2 perspective, for UE with UE-specific pre-compensation as a baseline it is up to gNB implementation to ensure a sufficient time on UE side for the Msg3 transmission.*

**Question 2.8: Do you agree with the proposed wording regarding Msg3 scheduling adaptation for UE with UE-specific delay pre-compensation?:**

* **From RAN2 perspective, for UE with UE-specific pre-compensation as a baseline it is up to gNB implementation to ensure a sufficient time on UE side for the Msg3 transmission.**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree |  |
| APT  | Agree  | “sufficient processing time“ might be around 2 ms (PDSCH processing time plus MAC lay parsing time) based on UE capability, but “sufficient time” is more general and less confusing.    |
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## RACH enhancements to accommodate the NTN environment

From RAN2#111e, the following was agreed regarding the inclusion of 2-step RACH in Rel-17 NTN [3]:

Agreements:

1. Both 2-step and 4-step RACH are supported in Rel-17 NTN. FFS enhancements to RACH to accommodate the NTN environment.

Companies are invited to provide initial enhancements to 2-step and 4-step RACH to accommodate the NTN environment (which are not otherwise covered in the other sections of this discussion document), or identify issues/enhancements specific to 2-step RACH.

**Question 2.9: Companies are invited to propose additional enhancements to RACH to accommodated the NTN environment, or issues/enhancements specific to 2-step RACH not already discussed in other sections.**

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| **Company** | **Description** |
| MediaTek | Include a TA report to the network in msg3 so that NW is aware of UE specific pre-compensation value for the service link. |
| APT  | Currently, UE initials 2-step RACH based on a configured threshold of RSRP measurement. However, this may have some issues due to no near-far effect in NTN. Some enhancement might be considered for measurement-based 2-step RACH.   |
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## Other RACH aspects

**Question 2.10: Are there any other identified issues and potential enhancements for RACH in NTN for Rel-17? Companies are invited to describe the issue/enhancement in the “Description” section.**

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| **Company** | **Description** |
| APT  | Current RACH resources are independently configured into 2-step and 4-step RA types, either based on different RACH occasions or PRACH preamble indexes. However, since no near-far effect in NTN, all UEs in an NTN cell may have a similar RSRP level, therefore either 2-step RA type or 4-step RA type resources will run out easily when NW configures both and UE determines based on its RSRP measurement.  |
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# HARQ Aspects

## Disabling uplink HARQ retransmission

From discussion in RAN2#111e, the following proposal was discussed:

*From a RAN2 perspective, uplink HARQ feedback for downlink transmission at UE receiver and HARQ uplink retransmission at UE transmitter can be enabled/disabled in Rel-17 NTN, but HARQ processes remain configured. The criteria and decision to enable/disable HARQ feedback is under network control and is signalled to the UE via RRC in a semi-static manner.*

Although agreement was reached in both RAN1 [5] and RAN2 [3] regarding the enabling/disabling of uplink HARQ feedback for downlink retransmission, discussion regarding the inclusion of uplink HARQ retransmission (i.e. the portion in red above) was inconclusive. Reference to SI discussion on enabling/disabling uplink HARQ retransmission can be found in TR 38.821 section 7.2.1.4 (included below for convenience):

*For NTN the network could disable HARQ uplink retransmission at the UE transmitter. Even if HARQ uplink retransmissions are disabled, the HARQ processes are still configured. The enabling / disabling of HARQ uplink retransmission could be configurable on a per UE, per HARQ process and per LCH basis. Details can be decided in a normative phase. And the LCP impact caused by disabling the HARQ uplink retransmission configuration can be discussed in the WI phase.*

And is again referenced (in a slightly modified form) in section 9.2 Recommendations from RAN2 in SI conclusions:

*enabling / disabling of HARQ uplink retransmission should be configurable per UE or per HARQ process. The LCP impact caused by disabling the HARQ uplink retransmission configuration and its impact on UE's uplink transmission should be discussed in the work item phase.*

**Question 3.1: From a RAN2 perspective, do you agree that HARQ uplink retransmission at the UE transmitter can be enabled/disabled in Rel-17 NTN as per RAN2 recommendations in SI conclusion? If ‘Disagree’ please justify why SI conclusion is no longer valid.**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | Uplink retransmission at the UE transmitter can be enabled/disabled in Rel-17 NTN as per RAN2 recommendations in SI conclusion |
| APT  | Agree  |  |
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RAN2 recommendations in the SI conclusion further mention that the granularity for disabling HARQ uplink retransmission can be configurable ‘*per UE or per HARQ process.*’

**Question 3.2: If ‘Agree’ to Question 3.1, what is the preferred granularity for enabling/disabling HARQ uplink retransmission from a RAN2 perspective?**

* **Option 1: configurable per HARQ process;**
* **Option 2: configurable per UE.**

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| **Company** | **Preferred Option** | **Additional comments** |
| MediaTek | Option 1 | Granularity for enabling/disabling HARQ uplink retransmission could be configured per HARQ process basis. |
| APT  | Option 1  |  |
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The TR additionally mentions other aspects regarding the enabling/disabling of HARQ specifically referring to HARQ feedback (i.e. HARQ processes remain configured, criteria to enable/disable is under network control, and signalled to the UE via RRC in a semi-static manner) which was agreed in RAN2#111e [3]. Companies are invited to comment whether these agreements are also valid for uplink HARQ retransmission (if agreed).

**Question 3.3: From a RAN2 perspective, which of the following statements agreed for UL HARQ feedback for downlink transmission are applicable to HARQ uplink retransmission?**

1. **HARQ uplink retransmission at the UE transmitter can be enabled/disable, but HARQ processes remain configured;**
2. **The criteria to enable/disable HARQ uplink retransmission is under network control;**
3. **Enabling/disabling HARQ uplink retransmission is signalled to UE via RRC in a semi-static manner;**

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| **Company** | **Statements** | **Additional comments** |
| **Agree** | **Disagree** |
| MediaTek | Option 1Option 2Option 3 | None |  |
| APT  | Option 1Option 2Option 3 |  |  |
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**Question 3.4: If RAN2 agrees that HARQ uplink retransmission at the UE transmitter can be enabled/disabled in Rel-17 NTN, should an LS be sent to RAN1?**

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| **Company** | **Send LS to RAN1? Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | Send an LS to RAN1 corresponding to enabling/disabling of HARQ uplink retransmissions at the UE transmitter. |
| APT  | Agree  |  |
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## drx-HARQ-RTT-Timers

### drx-HARQ-RTT-Timers behaviour when HARQ feedback is enabled

From RAN2#111e, the following proposal had large majority (25/27) support [2,6]:

* *If HARQ feedback is enabled, an offset is applied to the start of drx-HARQ-RTT-TimerDL and drx-HARQ-RTT-TimerUL for both LEO and GEO scenarios.*

Based on company feedback in RAN2#111e, there seems to be a general understanding that the timers require adaptation via an offset as per SI conclusion (and as captured in the WID). However based on further discussion it was was suggested that the offset may not need to apply to the start of the timers (as mentioned in the proposal), but instead used to extend the value range of the timers. Companies are therefore invited to provide additional clarification to the above proposal.

**Question 3.4: What is the preferred method to extend *drx-HARQ-RTT-TimerDL* and *drx-HARQ-RTT-TimerUL*?**

* **Option 1: offset is applied to the start of the timers;**
* **Option 2: offset is applied to the timer value range (i.e. existing values within value range increased by offset);**
* **Option 3: the timer value range is extended (i.e. additional values added to value range);**

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| **Company** | **Preferred Option** | **Additional comments** |
| MediaTek | Option 2 | These timers represent the minimum duration before a DL assignment for HARQ retransmission or a UL HARQ retransmission grant is expected by the MAC entity. In NTN, this duration needs to be extended by the UE specific RTD, i.e. the pre-compensation offset. Option 3 should not be supported as in that case the UE might be forced to monitor the DL for longer periods, thereby resulting in higher power consumption.  |
| APT  | Option1   | Less spec impact and easy to implement  |
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As in Section 2, should companies conclude that at least UE-specific delay is known at the UE and is to used for time/frequency synchronization, a baseline definition of timer offset values may be determined.

**Question 3.5: Do you agree that *drx-HARQ-RTT-TimerUL* and *drx-HARQ-RTT-TimerDL* offset is defined using UE-specific delay as baseline in LEO/GEO?**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree |  |
| APT  | Agree  |  |
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### drx-HARQ-RTT-Timers behaviour when HARQ feedback is enabled

In addition to the method of drx-HARQ-RTT-Timer offset (if HARQ feedback is enabled), should HARQ feedback be *disabled,* the following was proposed based on Phase 1 outcome [6]:

* *If HARQ feedback is disabled, drx-HARQ-RTT-TimerDL and drx-HARQ-RTT-TimerUL are not started for both LEO and GEO scenarios.*

Via feedback provided in Phase 2 [2], several companies mention *drx-RetransmissionTimerUL(DL)* may be useful to enable blind retransmission for improved reliability should UL HARQ feedback/HARQ UL retransmission be disabled. However, under current MAC specification [8], expiry of *drx-HARQ-RTT-TimerUL(DL)* is used as the trigger condition for the start of *drx-RetransmissionTimerUL(DL)* respectively (with the added DL condition that data of the corresponding HARQ process was not successfully decoded).

Therefore, should the drx-HARQ-RTT-Timers not be started as per the above proposal, under current specification the drx-Retransmission timers will also not be started. This may introduce limitations on blind retransmission unless further modification is adopted (e.g. introduction of additional start criteria for the drx-RetransmissionTimers).

Given the significant support for this proposal in previous discussion (23/27), and that discussion regarding blind retransmission is out of scope of this email discussion, rapporteur suggests the following compromise to avoid placing limitations on future solution options for blind retransmission:

* *If HARQ feedback is disabled, drx-HARQ-RTT-TimerDL and drx-HARQ-RTT-TimerUL are not started for both LEO and GEO scenarios. FFS modification of drx-RetransmissionTimerDL and drx-RetransmissionTimerUL to support blind retransmission, if agreed.*

**Question 3.6: Do you agree with the following proposal?**

* **If HARQ feedback is disabled, *drx-HARQ-RTT-TimerDL* and *drx-HARQ-RTT-TimerUL* are not started for both LEO and GEO scenarios. FFS modification of *drx-RetransmissionTimerDL* and *drx-RetransmissionTimerUL* to support blind retransmission, if agreed.**

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| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | There is no need to start drx-HARQ-RTT-TimerDL and drx-HARQ-RTT-TimerUL is HARQ feedback is disabled.If blind retransmission is needed, repetitions can already be configured by the network. For this first release of NTN, further enhancements are not needed |
| APT  | Agree  |  |
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# Summary

<To be generated pending company input>

# Conclusions

<To be generated pending company input>

# References

1. RP-201256 – “*Solutions for NR to support non-terrestrial networks (NTN)*” – Thales
2. R2-2008214 – “*Summary of [AT111][107][NTN] Pre-compensation and other MAC issues Phase 2*” – InterDigital
3. R2-2008122 – “*Report from Break-out session on R16 eMIMO, CLI, PRN, RACS and R17 NTN and REDCAP*” – RAN2 Vice Chairman (ZTE Corperation)
4. R1-2007290 – “*Feature lead Summary on enhancements on UL time and frequency synchronization for NR NTN*” – Thales
5. Chairman’s Notes RAN1#102-e 8.4 v004 – RAN1 Vice Chair
6. R2-2008188 – “*Summary of [AT111][107][NTN] Pre-compensation and other MAC issues* ” – InterDigital
7. TR 38.821 - Solutions for NR to support non-terrestrial networks (NTN) v16.0.0
8. TS 38.321 – Medium Access Control (MAC) protocol specification v16.1.0