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:\Data\3GPP\RAN2\Inbox\R2-2008214.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*
* *FFS: The TA margin, if needed and indicated by the network (in order to account for the TA estimation uncertainty)*

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)?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | UE can derive UE-specific delay based on its GNSS implementation in LEO/GEO deployments |
| APT | Agree |  |
| Nomor Research | Agree | UE can and shall derive UE-specific delay based on its GNSS implementation in NTN. UE-specific delay means total delay for UE-gNB-UE (NOT reference point). |
| Thales | Agree | The UE specific RTD (Round-Trip Delay) can be autonomously acquired by the UE based on its GNSS.  **But** for MAC timers extensions what is needed is the UE-gNB RTD. Not only the UE specific RTD. Indeed:   * If the GNSS assisted RTD acquisition is based on the satellite ephemeris (broadcasted satellite position and velcoity):   **UE-gNB RTD = UE specific RTD + Common RTD**:  UE specific RTD = Service link RTD = 2xT\_C  🡺 Autonomously acquired by the UE based on its GNSS acquired position and the serving satellite ephemeris.  Common RTD= gNB to satellite RTD = 2xT\_A + 2xT\_B 🡺 Network indication     * If the GNSS assisted RTD acquisition is based on time stamp:   UE-gNB RTD = UE specific RTD  UE specific RTD 🡺 Autonomously acquired by the UE based on its GNSS acquired reference time and the reference time indicated by the network |
| LG | Agree but | Above Rel-17, RAN2 should consider the UE without GNSS. Givne the UE without GNSS, RAN2 should discuss the solution for the UE with GNSS as well as the UE without GNSS. |
| CATT | Agree | We observed that all UEs will respond the SI change indication frequently if the common TA(e.g feeder-link delay) is broadcast via SI message, becuase the common TA(e.g feeder-link delay) changes frequently with the moving of satellite. The SI change indication will happen frequently accordingingly.  So we support the User specific TA which is estimated by the UE, but the Common TA(e.g feeder-link delay) not indicated via SI, or optionally indicatged by network. |
| Nokia | Tentatively Agree | Based on RAN1's agreements, R17 NTN at least support the UE to be able to compensate for timing offset and frequency offsets based on GNSS implementation. In current RAN1 agreements, there has been no agreement on excluding UEs that are not supporting pre-compensation capability, and the above agreement covers at least the RRC idle/inactive UE, so no explicit agreement on RRC connected mode UE. Further, in RAN1 there was an agreement to introduce k\_offset to enhance timing relationships (for instance in relation to transmission timing of RAR grant scheduled PUSCH). |
| Ericsson | Disagree | RAN2 shall wait for RAN1 conclusion on the TA estimation before going further.  We note that the last line of second RAN1 agreement is missing.  The Option 1 in second RAN1 agreement above seems to only compensate the service link and may need to be combined with the Common TA in same agreement to compensate for feeder link component. Alternatively the UE may need to know the gateway location and use satellite ephemeris to calculate the feeder link component. |
| Qualcomm | Agree | RAN2 has already agreed UE is capable of GNSS, so it can determine its position based on GNSS. RAN2 has also agreed satellite ephemeris is provided to UE. Simply, UE can derive the distance between UE and satellite and hence time/frequency compensation.  It should also be clear that if time reference is at satellite, TA is simply the delay between UE and satellite (not UE-gNB RTD). We should keep it simple. |
| Loon, Google | Agree | Agree with Thales that Common delay should be handled |
| Lenovo | Agree but | It is obvious that UE can derive service link delay based on its GNSS implementation. But we at least need to clearly define “common delay” e.g. whether feeder link delay is included. Additionally, RAN2 may discuss the solution for the UE without GNSS or when GNSS is unavailable in the future. |
| Apple | Agree but | We agree with the sentiments of LG and Nokia. RAN2 will need to possibly revisit and include additional criteria based on RAN1 agreements for UEs that do not have pre-compensation capability. But we do agree that the UE can derive UE-specific delay based on GNSS capabilities. |
| OPPO | Agree for UEs with time/frequency precompesation capability using GNSS, but | We should also consider UEs without time/frequency precompesation capability using GNSS. For these UEs, common delay solution is required. |
| Xiaomi | Agree | But RAN1 has not ruled out UE without pre-compensation capability, RAN2 still need to decide whether UE with GNSS capability is capable of pre-compensation or not. |
| Panasonic | Agree |  |
| Huawei | Agree | Agree with Thales that the UE specific delay calculated based on GNSS capability and ephemeris data is for the service link. A common delay for the feeder link should be broadcast by the gNB. |
| NEC | Agree |  |
| Samsung | Agree | We also like to support common TA indication by the network so that a large portion of the overall delay can be compensated by the UE even if an accurate GNSS-based UE location is unavailable. Note that the UE may not be able to reliably and accurately determine its GNSS-based location although it is GNSS-capable. The network-indicated common delay can serve as a fallback mechanism. Furthermore, the overall common delay can be pre-defined as a function of the type of the NTN (e.g., GEO vs. LEO) with a default satellite-Earth distance. An optional scaling factor can be defined to account for different satellite-Earth distances for a given type of NTN (e.g., LEOs at 600 km vs LEOs at 1000 km). |
| Vodafone | Agree | Agree with Thales’s illustration of the common and specific round trip delays involved with various Satellite Systems i.e. LEO or GEO |
| Intel | Agree | Given network provide location information in SI, UE can use GNSS to get its location information and hence to estimate the UE specific delay. |
| Sequans | Agree | Need to clarify what is UE-specific delay.  It seems it is RTD to RP (RP being gNB in option 2 but not in option 1), but then we need to add common RTD to derive the useful UE-gNB RTD. |

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?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree | *ra-ContentioResolutionTimer* offset should be defined using UE-specific delay as baseline in LEO/GEO |
| APT | Agree |  |
| Nomor Research | Agree | UE-specific delay saves UE power |
| Thales | Agree | **But** as already mentioned in our comment for question 2.1; UE-specific RTD is not enough. For ra-ContentioResolutionTimer offset we need to consider the whole RTD between UE and gNB:  **UE-gNB RTD = UE specific RTD + Common RTD**  The common RTD is equal to the RTD on the feeder link and the gNB to NTN GW RTD |
| LG | Disagree | Considering the UE without GNSS, RAN2 should discuss the solution for the UE with GNSS as well as the UE without GNSS. Thus, we prefer the common offset solution broadcasted by the network. |
| CATT | Agree |  |
| Nokia | Tentatively Agree | If UE has the pre-compensation capability,we think using the UE-specific delay based offset is reasonable. |
| Ericsson | Disagree | We propose to use the DL timing as reference for starting the CR window. This makes the TA, used to transmit Msg3, not affect the start of the CR window and avoid misalignment if TA estimation is not accurate. |
| Qualcomm | Agree | To clarify, this is start offset. Yes the start offset is based on UE specific TA. It is clear UE needs common feeder link RTD as well.  To further clarify,  If offset is applied from the time slot where preamble is transmitted, then offset = UE specific service link RTD + common feeder link RTD. |
| Loon, Google | Agree | Agree with Thales that common delay should be handled |
| Lenovo | Agree but | The offset can be defined using UE-specific delay but considering transparent mode we need to clearly define “common delay” e.g. whether feeder link delay is included. |
| Apple | Agree but | Again similar to Question 2.1, the final outcome of this solution will depend on pre-compensation capabilities off UE and RAN1 outcome. |
| OPPO | Agree | We think this is independent of Q2.1. After Msg3, UE has already acquired it’s absolute TA (no matter whether UE has time/frequency precompesation capability using GNSS) and can apply it as the ra-ContentioResolutionTimer offset. |
| Xiaomi | Agree but | Common delay needs also to be considered in UE specific delay. |
| Panasonic | Agree but | As mentioned by Thales, whole RTD (i.e. UE-specific RTD + common RTD) needs to be taken into account. |
| Huawei | Agree | Agree with others that common delay should be considered. We think the common delay can be broadcast by the gNB. |
| NEC | Agree |  |
| Samsung | Agree | Additional support for network-indicated common delay. |
| Vodafone | Agree | for satellites e.g. LEOs with elliptical orbit around the earth, this round-trip delay could range considerably and therefore a ‘common delay’ should be complimented with specific delays associated with large orbital fluctuations. |
| Intel | Agree | This way, UE can give better estimation of the delay and adjust the resolution timer accordingly. |
| Sequans | Agree but | Baseline should be the total delay (UE specific + common delay) |

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)**

|  |  |  |
| --- | --- | --- |
| **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 |  |
| Nomor Research | Agree | Offset of UE-specific delay should also be applied for start of msgB-ResponseWindow |
| Thales | Agree | Similar to our comments in the prevous questions, For *ra-ResponseWindow* offset we need to consider the whole RTD between UE and gNB:  **UE-gNB RTD = UE specific RTD + Common RTD**  The common RTD is equal to the RTD on the feeder link and the gNB to NTN GW RTD  Also, we need such offset to delay the start of msgB-ResponseWindow to compensate the high RTD in 2-step RACH |
| LG | Disagree | Considering the UE without GNSS, RAN2 should discuss the solution for the UE with GNSS as well as the UE without GNSS. Thus, we prefer the common offset solution broadcasted by the network |
| CATT | Agree | ra-ResponseWindow offset is defined using UE-specific delay as baseline in LEO/GEO. |
| Nokia | Tentatively Agree | If UE has the pre-compensation capability,we think using the UE-specific delay based offset is reasonable. |
| Ericsson | Disagree | We propose using the DL timing as reference for starting the RAR window (or MsgB window). This makes the TA used (to transmit the preamble or MsgA) not affect the start of the RAR window (or MsgB window), and removes any uncertainty if the UE will be listening for RAR when the accuracy of TA used for the preamble transmission is uncertain. |
| Qualcomm | Agree | Yes same as start offset to ra-ContentioResolutionTimer. |
| Loon, Google | Agree |  |
| Lenovo | Agree but | The offset can be defined using UE-specific delay but considering transparent mode we need to clearly define “common delay” e.g. whether feeder link delay is included. |
| Apple | Agree but | Again depends on if UE without pre-compensation capabilities are agreed in RAN1. For making this future proof, we can alternately have a common offset solution broadcasted by the network as suggested by LG. |
| OPPO | Disagree | We should also consider Ues without time/frequency precompesation capability using GNSS. For these UEs, common delay solution is required. |
| Xiaomi | Agree but | Common delay needs also to be considered in UE specific delay. |
| Panasonic | Agree but | As mentioned by Thales, whole RTD (i.e. UE-specific RTD + common RTD) needs to be taken into account. |
| Huawei | Agree | Similar to ra-ContentioResolutionTimer. |
| NEC | Agree |  |
| Samsung | Agree | Additional support for network-indicated common delay. |
| Vodafone | Agree | for satellites, e.g. LEOs, with elliptical orbit around the earth, this delay could range considerably and therefore a ‘common delay’ should be complimented with specific delays associated with large orbital fluctuations. |
| Intel | Agree | This way, UE can give better estimation of the delay and adjust the RA response window accordingly. |
| Sequans | Agree but | As discussed earlier, common delay also needed too to derive whole RTD. |

**Question 2.4: If “Agree” to Question 2.3, should and LS be sent to RAN1?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Nomor Research | Agree | LS should be sent to RAN1 |
| Thales | Agree |  |
| LG | Disagree | RAN1 can refer the RAN2 decision. |
| CATT | Agree |  |
| Nokia | Disagree | It is up to the conclusion of Question2.1. If UE with GNSS capability but without pre-compensation of timing is still in the scope of R17 NTN, then common delay offset for the timer should be broadcasted to UE as well. No LS should be sent to RAN1 before conclusion reached on this case. |
| Ericsson | Disagree | An LS can be sent to ask for RAN1 opinion on starting RAR window, MsgB window, and CR window based on the DL timing instead of the UL timing. |
| Qualcomm |  | Ok to send LS. |
| Loon, Google | Agree |  |
| Lenovo | Agree | LS including RAN2 understandings can be sent to RAN1. |
| Apple | Disagree | Again it is up to the conclusion of Question 2.1. Depends on if the UE has pre-compensation capabilities or not. |
| OPPO | Disagree |  |
| Xiaomi | Agree |  |
| Panasonic | Agree to send LS to RAN1 |  |
| Huawei | Agree | Nice to have an LS. The modification to the start of RAR window has RAN1 impact as well. |
| NEC | Agree |  |
| Samsung | Agree | Additional support for network-indicated common delay. |
| Vodafone | Agree | This elliptical orbit and the associated round-trip variation and delays were discussed in a breakout session on one of RAN2’s previous meeting and as explained we would require a ‘look-up table’ for the UE to calculate these round-trip delays with orbital fluctuations |
| Intel | Agree |  |
| Sequans |  | No strong view |

### 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?**

|  |  |  |
| --- | --- | --- |
| **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. |
| Nomor Research | Agree |  |
| Thales | Agree | There is no need to extend the ra-ResponseWindow and msgB-ResponseWindow |
| LG |  | If the common offset is used for LEO/GEO, the extension of the RAR window may be required. |
| CATT | Agree | Extension of the *ra-ResponseWindow* is not needed in LEO/GEO. |
| Nokia | Agree with comments | We want to clarify UE-specific delay in the proposal is from UE to gNB instead of from UE to reference point, because both of them are mentioned in Section2.1.1. Additionally, the offset applied to ra-ResponseWindow should be two times of UE-specific delay (from gNB to UE).  E.g. If the UE can estimate or get the total round-trip delay between UE and gNB and apply the exact total delay as offset to start ra-ResponseWindow, there is no need to extend the window, otherwise, the window may be extended to cover 2 times of maximum differential delay. |
| Ericsson | Agree | Extension of RAR window is not connected to how the RAR window is started, it is connected to if TA can be accurately estimated by the UE in which case there is no need to extend the RAR window.  If RAN1 decides that accurate TA compensation is not possible for all users, we may revisit this assumption. |
| Qualcomm | Agree | Yes this one of the many benefits of UE specific TA. |
| Loon, Google | Agree |  |
| Lenovo | Agree | No need of extension if offset is introduced and appropriately applied. |
| Apple | Agree but | We agree with LGs view here that a common delay solution can be utilized for both UEs with and without pre-compensation capabilities. In the case with UE with GNSS and pre-compensatoin capabilities an extension of ra-ResponseWindow is not needed. |
| OPPO | Agree for UEs with time/frequency precompesation capability using GNSS, but | Since the common delay based offset should be supported for the UEs without available position information, extension of *ra-ResponseWindow* value is needed for GEO, in which case maximum differential RTD within the cell is 20.6ms. |
| Xiaomi | Agree |  |
| Panasonic | Agree | With UE based pre-compensation and feeder link delay, UE can estimate total round trip delay between UE and gNB and apply total delay as a offset to start ra-ResponseWindow. Hence, extension may not be required. |
| Huawei | Agree | The maximum differential delay can be compensated if UE specific delay is accurate. |
| NEC | Agree |  |
| Samsung | Agree |  |
| Vodafone | Agree |  |
| Intel | Agree | If the starting of the ra-responseWindow is adjusted correctly, then the extension is not needed since the extension is to compensate the propoagation delay. |
| Sequans | Agree |  |

### 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.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Additional comments** |
| MediaTek | No | With UE-specific RTD precompensation, preamble ambiguity will not be an issue. |
| APT | No |  |
| Nomor Research | No | With UE-specific RTD compensation, preamble ambiguity is not an issue. However, from our perspective this is an RAN1 issue in general. |
| Thales | No | With UE-based pre-compensation of RTD, the delay associated with msg1 transmission will be updated and there will be no preamble ambiguity |
| LG |  | The preamble ambiguity can be resolved by network implementation. |
| CATT | No | Preamble ambiguity is not an issue if UE-specific RTD is compensated. |
| Nokia | No with comments | Same comment as Q2.5. |
| Ericsson | No |  |
| Qualcomm | No | With UE specific TA, all UEs target the same RA occasion. Some inaccuracy can be handled by existing PRACH formats. So there should be no preamble ambiguity. |
| Loon, Google | No |  |
| Lenovo | No | RAN2 may need to discuss the solution for the UE without compensation capability in the future. |
| Apple | No | If a UE-specific pre-compensation is present, there is no ambiguity. But RAN2 should discuss cases where there are UEs without pre-compensation capabilities. |
| OPPO | No for UEs with time/frequency precompesation capability using GNSS, but | Since the common delay based compensation should be supported for the UE without capability of TA pre-compensation using GNSS, preamble ambiguity is still an issue. |
| Xiaomi | No |  |
| Panasonic | No |  |
| Huawei | No |  |
| NEC | No |  |
| Samsung | Agree | Pre-compensation should suffice. |
| Vodafone | No |  |
| Intel | No |  |
| Sequans | No |  |

### 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**

|  |  |  |
| --- | --- | --- |
| **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. |
| Nomor Research | No strong view |  |
| Thales | Both options | It is true that autonomous TA acquisition based on GNSS and time stamp broadcast (e.g. ReferenceTimeInfo-r16) requires high-level integration of GNSS module and NR module in device and gNB.  Note that time stamp broadcast (e.g. ReferenceTimeInfo-r16) can already be supported using Rel-16 specifications.  On the other hand, for option 1 we need to discuss the implication of UL timing alignment requirements on the expected accuracy of :  The satellite position knowledge at UE side and the UE position knowledge at UE side.  Also, depending on UE motion on the earth, option 1 may also require UE to use its GNSS capability very often to derive its position, e.g. 1200 km/h (e.g. aircraft) and 500 km/h (e.g. high speed train) |
| LG |  | If the estmation of the user specific TA is required, option 1 can be a simple option. |
| CATT | Option 1 | We support the User specific TA which is estimated by the UE based on its GNSS acquired position.  If the reference time is indicated by the network in option 2, UE should get GNSS/UTC time accurately at first. Furthermore, option 1 can support the compensation of Doppler effect. |
| Nokia | Option 2 | From RAN2 perspective, to obtain the full RTD from the UE to land-based gNB, Option1 requires not only UE estimated delay for service link (from satellite to UE) but also the common delay for feeder link (from gNB to satellite), which means gNB need to broadcast common delay to UEs (e.g. it is challenging in LEO with moving satellite) to facilitate UE do full UE-specific TA compensation.  However, in Option2, the full RTD on the Uu interface (feeder and service link) can be estimated by the UE based on reference time IE in SIB9, which removes potential source of errors/inaccuracies when determining the UE-to-satellite distance/delays and also removes the requirement to broadcast exact common delay from gNB to UE for full TA compensation. Furthermore, Option2 is more future proof when thinking ISL in future release.  With Option 2, the potential error sources from GNSS system may be reduced, since it relies only on time stamps, while option 1 relies on accurate position combined with an associated estimate of time delay between UE and satellite, which is not representative of the entire gNB-to-UE delay. |
| Ericsson | Both are possible | RAN2 shall not waste time on this discussion until RAN1 decision is taken.  One of the options shall be selected, we shall not have both options in the spec. |
| Qualcomm | Option 1 | Because option2 is not helpful for frequency compensation. In addition option 2 requires both UE maintain clock based on GNSS and also acquire SIB9 to calculate the time compensation. |
| Loon, Google | Option 2 | Option 2 is better for HAPS and systems where ephermris is not as crisp as LEOs |
| Lenovo | Both options | Option 1 is better for LEO as satellite ephemeris is necessary for many purposes including mobility and frequency compensation can also use it. But HAPs may need a choice using Option 2 especially the operator may not want to expose gNB location with security concerns. |
| Apple | Option 1 | A similar discussion is also happening in RAN1. So maybe waiting for that outcome is also an option. |
| OPPO | Option 1 | Option 1 can work for both time and frequency precompensation, while with option 2, it is hard to do frequency precompensation. |
| Xiaomi | Option 1 | Option 1 is better than option 2, because location information of satellite and UE is helpful not only for TA pre-compensation but also for mobility, and satellite ephemeris information is also useful for frequency compensation. Option 2 can only be used for TA compensation and requires UE to frequently keep clock sync with GNSS satellite, which may consume more power. |
| Panasonic | Option 1 | In option 2, for LEO case reference time could change very frequently which could be challenging if such value is broadcasted in SIB. |
| Huawei | Option 1 | Agree with CATT/Qualcomm/Oppo that Option 2 does not benefit frequency compensation which relies on GNSS capability. Besides, Option 2 only supports full TA, thus lacks flexibility.  Furthermore, it is already agreed in the previous meeting that the ephemeris data will be broadcast:   1. The satellite ephemeris should be provided to UE, at least for Satellite/HAPS ephemeris based cell selection and reselection (FFS what the term satellite/HAPS ephemeris actually means).   With ephemeris information and GNSS capability, we think Option 1 is simple and natural. |
| NEC |  | We should wait for a decision from RAN1. |
| Samsung | Option 1 | The topics of propagation and processing delays, platform location (e.g., location of a satellite or HAPS), and time reference (Option 2) need to investigated in more detail (e.g., via email) so all contributing companies have the same understanding of the overall processing. For example, the GNSS-based platform location reported by the platform to the NTN-GW is “measured” at time t1. The NTN-GW may (or may not) adjust the reported platform location and time to reflect the instant t2 when it has received the location report. The gNB may (or may not) further adjust the NTN GW-reported platform location and time to reflect the location at the current instant t3 when a SIB is constructed. The UE needs to know if it is getting the platform location correspomding to t1, t2, or t3. We need to know typical processing times at the platform, the NTN-GW, and the gNB. The target or achievable accuracy of the platform location and time reference are unclear at this time. Since the UE needs to use the platform location to derive timing, distance, and elevation information, we suggest to discuss this topic in more detail. The achievable resolution of time in Option 2 should be clarified (e.g., X seconds or Y ms). |
| Vodafone | Primarily Option 1 | For a UE in a Satellite coverage areas Option 1 would the primary option however, it is unclear how the UE would be able to obtain Timing Advance (TA) from a terrestrial network , which is out of coverage, unless, as Qualcomm has stated the UE demands SIB9 to be obtained by the Satellite network ? |
| Intel | Option 1 | We think that by using the location of the UE from GNSS and the gNB, the UE can get more accurate estimation. Thought option 2 seems to be feasible. |
| Sequans | Wait for RAN1 | From a pure RAN2 perspective, we don’t see much impact that would justify a preference. The main discussion is related to required accuracy (time or position), implementation impact, power consumption at UE, feasibility of frequency compensation (for Option 2), etc. We assume those aspects are better discussed by RAN1. |

## 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.**

|  |  |  |
| --- | --- | --- |
| **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. |
| Nomor Research | Agree |  |
| Thales | Agree |  |
| LG |  | If the common TA and offset is used in NTN, this issue should be discussed futher. |
| CATT | Agree |  |
| Nokia | Agree |  |
| Ericsson | Agree with intent | We prefer a bit more specific:  From RAN2 perspective, for UE with UE-specific pre-compensation as a baseline it is up to gNB implementation to take into account UE processing capabilities to ensure a sufficient time on UE side for the Msg3 transmission. |
| Qualcomm | Agree | It will depend on scheduling Koffset. The only difference compared to NR is additional parameter “scheduling Koffset” and network will set appropriate value of the Koffset to cover the UE’s TA or worst case TA. |
| Lenovo | Agree |  |
| Apple | Agree | It is already agreed in RAN1 to use a common timing offset to be broadcasted from NW that can be used for Msg3 transmission. |
| OPPO | Agree with comments | We propose to remove “**as a baseline**”, since we are not ready to do any prioritization. |
| Xiaomi | Agree |  |
| Panasonic | Agree |  |
| Huawei | Agree |  |
| NEC | Agree |  |
| Samsung | Agree |  |
| Vodafone | Agree | It needs to be clarified where how this offset is calculated, bearing in mind that for LEOs at least the satellite orbit is elliptical and depending on the position of the satellite, this offset would be different |
| Intel | Agree |  |
| Sequans | Agree |  |

## 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.**

|  |  |
| --- | --- |
| **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. |
| Nomor Research | As indicated in our answer to Question 2.3: Introduce an offset of UE-specific delay for the start of msgB-ResponseWindow.  NTN cells/beams are large in comparison to TN and therefore could cover a significantly larger number of UEs attempting to access the network. This could raise an issue regarding limited RACH capacity. It should be evaluated, if there are enhancements necessary to limit 2-step RA. |
| Thales | Introduce K\_offset to enhance the transmission timing of RAR grant scheduled PUSCH. For Koffset used in initial access, the information of Koffset is carried in system information.  Also, in case of autonomous acquisition of the TA at UE, only the UE knows the full TA, therefore, UE needs to report its autonomous TA in msg3. |
| LG | The legacy 2-step RACH can be used for NTN except for the introduction of the offset for MsgB. |
| CATT | UE may report the TA value via MsgA in 2-step RACH. |
| Nokia | If both 2-step and 4-step RACH are supported in one NTN cell, how to select RA type should be further studied on top of legacy RSRP threshold. |
| Ericsson | RAN1 decided the timing K\_offset to be used in initial access must be provided to the UEs in SI broadcasting.  It is beneficial for the system if the TA used by the UE is reported to the gNB as soon as possible, possibly in Msg3 of 4-step or MsgA of 2-step RA. If used TA is not include in the MsgA, the gNB scheduling of MsgB must, in same way as for Msg3, assume a worst case for the TA used. We may not require the TA to be include in Msg3/MsgB as that may decrease the coverage.  The start of *msgB-ResponseWindow* is specified in RAN1 spec, but the same method as for the start of the RAR window can be used.  RACH less handover is beneficial for connected mode UEs in NTN, as we avoid one RTT when the UEs can estimate the required TA in a new cell. It may decrease the RACH load and thereby decrease the RA collisions, and it may also be more resource efficient that relying on 2-step RA (which have a similar delay). |
| Qualcomm | For 4 steps RACH, Msg3 has no space to include TA report, TA report should be included in Msg5.  For 2 step RACH, MsgA can include the TA report. |
| Lenovo | For TA pre-conpensation, RAN2 may discuss the solution for the UE without GNSS or when GNSS is unavailable in the future.  For preamble ambiguity, RAN2 may need to discuss the solution for the UE without compensation capability in the future.  For 2-step RACH, the near-far effect may not be obvious as that in TN, i.e. there may not be a clear difference in RSRP between cell center and cell edge UEs. As a result the RSRP criterion for RA type selection may not work well. |
| Apple | Introuce a k\_offset as suggested by Thales above which already seems to be agreed in RAN1. |
| OPPO | The existing RSRP-based RA type selection needs to be adapted to take UE location information into account in NTN. |
| Xiaomi | TA report in msg3 |
| Panasonic | We share same view as Thales. |
| Huawei | UE should be able to include the estimated timing advance, either in MSG3 or MSG5. |
| Samsung | Support for Configured Scheduling, Semi-Persistent, and Dynamic Scheduling can be considered to reduce the interruption in user traffic transfer in both downlink and uplink while keeping the PUSCH RRC signaling (associated with a 2-step RA procedure) and the PUSCH user traffic transfer (proposed) separate. This will enable the network to independently control QoS/reliability of RRC Signaling (e.g., RRC Reconfiguration Complete message) and UL user traffic transfer. Furthermore, the UE can be asked to monitor for suitable PDCCHs and PDSCH for DL user traffic and DL/UL asisgnments for user traffic. In other words, the PUSCH assignment specified as part of the 2-step RA procedure can be used for RRC signaling only and a separate PUSCH assignment (in the form of Configured Scheduling, Semi-Persistent, and/or Dynamic Scheduling) can be designated for user traffic. To facilitate Configured Scheduling and Semi-Persistent Scheduling for the UL, the UE can be configured to send a “handover Buffer Status Report” along with the Measurement Report message so that the network can decide whether to activate such intra-handover user traffic transfer or not. |
| Vodafone | As Thales has indicated K\_offset should be used. |
| Intel | We think the UE can report TA to the network. |

## 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.**

|  |  |
| --- | --- |
| **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. |
| Samsung | **Topic: Intra-handover User Traffic Transfer**. We like the flexibility of supporting both 4-step and 2-step RA procedures for handover. The network can choose whether to configure just one type of RA procedure or both procedures for a given UE for handover. While the RA procedure is ongoing during handover, there is a significant user traffic interruption in an NTN between the RRC Reconfigration message (carrying the handover command) and the RRC Reconfiguration Complete message. We suggest the support of user traffic transfer between these messages to minimize the overall traffic interruption between the RRC Reconfiguration. In particular, since the UE is doing pre-compensation, PUSCH transmissions (with some frequency guard band until RAR is received) can be processed by the target gNB. The existing configured scheduling, semi-persistent scheduling, or dynamic scheduling procedures can be enhanced to support such user traffic transfer. To save additional radio resources and to ensure increased reliability of signaling during the random access procedure, a 4-step RA procedure in conjunction with user traffic transfer could be a good overall solution. |
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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 |  |
| Nomor Research | Agree, but | In UL, HARQ retransmission usually depend on gNB’s PUSCH decoding result of initial transmission. These retransmissions can be enabled/disabled in Rel-17 NTN. However, UL HARQ retransmissions as retransmissions of a TB in a bundle or retransmissions based on blind scheduling are still supported. |
| Thales | Agree | We need to discuss LCP impact caused by disabling the HARQ uplink retransmission configuration and its impact on UE's uplink transmission |
| LG | Agree |  |
| CATT | Agree |  |
| Nokia | Agree with comments | We think the SI conclusion is to avoid UL HARQ stalling by disabling HARQ uplink retransmissions which always rely on previous PUSCH transmission decoding result of the same HARQ (i.e. long RTT to wait). So, we prefer to update it as below:  “HARQ uplink retransmission relying on the decoding result of previous PUSCH transmission at the UE transmitter can be enabled/disabled in Rel-17 NTN”  We are also fine to current proposal if majority view is that, disable HARQ uplink retransmission means disable all types of retransmission including slot aggregation as well as blind retransmissions |
| Ericsson | Disagree | The benefit for NTNs is to enable the gNB and UE to reuse one HARQ process ID before a full HARQ RTT has passed. This enables peak throughput even when the number of HARQ processes is less than needed to fill the HARQ RTT, and the cost is that there can be no HARQ retransmissions on the reused HARQ process.  Obviously the HARQ feedback sent in UL for DL transmissions becomes useless for HARQ processes that are intended to be reused, but for UL transmissions no such feedback exist today (besides in NR-U). The UE shall always follow the grants/assignments that the gNB sends to it, be it with or without the NDI toggled.  Today one HP ID can not be reused while a drx-HARQ-RTT is running (MAC spec issue, a timer value of zero is already available in the spec):  -    *drx-HARQ-RTT-TimerDL* (per DL HARQ process except for the broadcast process): the minimum duration before a DL assignment for HARQ retransmission is expected by the MAC entity;  -    *drx-HARQ-RTT-TimerUL* (per UL HARQ process): the minimum duration before a UL HARQ retransmission grant is expected by the MAC entity;  Also RAN1 specifies requirements on not reusing a HARQ process ID in 38.214 clause 5.1 and 6.1:  The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Clause 9.2.3 of [6]  …  Thus for DL, the gNB cannot send a new DL assignment for a given HARQ process ID until after (about a) half a RTT has passed since last use of the HPID.  …  The UE is not expected to be scheduled to transmit another PUSCH by DCI format 0\_0, 0\_1 or 0\_2 scrambled by C-RNTI or MCS-C-RNTI for a given HARQ process until after the end of the expected transmission of the last PUSCH for that HARQ process.  The meaning of last sentence for UL may be discussed, but the conservative interpretation (in Rel 15) is that the UE cannot receive a new grant for same HP ID before the end of the PUSCH transmission. Thus at least one or two slots (depending on CORSET, timing advance and Tproc2 and SCS) has to pass before gNB may reuse the same HP ID in an UL grant.  Thus “HARQ disabling” means 1) UE do not send HARQ feedback in UL for the DL transmissions, 2) gNB may schedule the same HARQ process ID in consecutive PDSCH/PUSCH allocations (using the same or toggled NDI).  Note that for UL we only need to allow a HP ID in consecutive PUSCH allocations, no need to signal this to the UE by RRC for specific HARQ process IDs.  Note that UEs already in Rel 15 had optional features pdsch-RepetitionMultiSlots/pusch-RepetitionMultiSlots where UEs receive/transmit on one HP ID in consecutive PDSCH/PUSCH allocations, though that is after receiving one assignment/grant for the first allocation only.  We propose modified the agreements from last meeting as follows:  **Proposal: From a RAN2 perspective, when a downlink HARQ process is disabled, the UE do not send uplink HARQ feedback for downlink transmissions scheduled on the disabled HARQ process.**  **Proposal: Enabling/disabling uplink HARQ feedback for downlink transmissions is under network control and is signalled to the UE via RRC in a semi-static manner.**  **Proposal: From a RAN2 perspective, when a DL HARQ process is disabled, the given DL HARQ process can be used in consecutive PDSCH allocations for new transmissions or retransmissions (pending RAN1 input on feasibility).**  **Proposal: From a RAN2 perspective, a given UL HARQ process can be used in consecutive PUSCH allocations for new transmissions or retransmissions (pending RAN1 input on feasibility).**  **Proposal: Send LS to RAN1 about the feasibility of these proposals.** |
| Qualcomm | Agree | It is also possible that UL HARQ process is stalled. So it should also be enhaced. |
| Loon, Google | Agree |  |
| Lenovo | Agree |  |
| Apple | Agree |  |
| OPPO | Agree with comments | We would like to clarify the wording as “HARQ uplink retransmission based on PUSCH decoding results at the UE transmitter can be enabled/disabled in Rel-17 NTN”. |
| Xiaomi | Agree | From our point of view, it only refers to blind UL retransmission(i.e. gNB schedules retransmission before acquiring the decoding result) . We prefer to clarify if it is the right understanding. |
| Panasonic | Agree |  |
| Huawei | Agree with comments | We understand the concern from Nomor and Nokia is that, if we capture the agreement this way, blind retransmission and TTI bundling will also be disabled if HARQ retransmission is configured as “disabled”.  Since “PUSCH decoding” is closely related to network implementation, we suggest adding a clarification in the brackets:  *From a RAN2 perspective, uplink HARQ feedback for downlink transmission at UE receiver and HARQ uplink retransmission (not including slot aggregation) 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.* |
| NEC | Agree | We want to clarify that UL HARQ retransmission here means the scheduled retransmission based on failed decoding only. |
| Samsung | Agree |  |
| Vodafone | Agree |  |
| Intel | Agree |  |
| Sequans | Agree but | As it is the SI conclusion.  But need to clarify what this means exactly (repetitions/bundle, blind retransmissions, or scheduled retransmissions following failed decoding). |

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.**

|  |  |  |
| --- | --- | --- |
| **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 |  |
| Nomor Research | Option 1 | UE can request for different services. |
| Thales | Option 1 | Same as for HARQ feedback for downlink transmission, enabling/disabling HARQ uplink retransmission should be at least configurable per HARQ process |
| LG | Option 1,  Option 2 |  |
| CATT | Option 1 | Per HARQ process is more flexible. |
| Nokia | Option 1 | It could be left transparent to the UE, as this is controllable through the NDI on the scheduling DCI, but if LCP is to be impacted by pre-knowledge at the UE side, this should be indicated on per HARQ process. |
| Ericsson | Option 1 |  |
| Qualcomm | Option 1 | It should be same as DL HARQ process. |
| Loon, Google | Option 1 |  |
| Lenovo | Option 1 |  |
| Apple | Option 1 | Per HARQ process |
| OPPO | Option 1 |  |
| Xiaomi | Option 1 |  |
| Panasonic | Option 1 | Option 1 is sufficient. Option 2 can be achieved with option 1 by enabling/disabling HARQ UL retransmission for all HARQ processes. |
| Huawei | Option 1 |  |
| NEC | Option 1 | We prefer to align with UL HARQ feedback for DL transmission. |
| Samsung | Option 1 | Option 1 provides more flexibility compared to Option 2. |
| Vodafone | Option 1 |  |
| Intel | Option 1 |  |
| Sequans | Option 1 |  |

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;**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Statements** | | **Additional comments** |
| **Agree** | **Disagree** |
| MediaTek | Option 1  Option 2  Option 3 | None |  |
| APT | Option 1  Option 2  Option 3 |  |  |
| Nomor Research | Statements 1, 2 and 3 |  | Regarding statement 1, we would prefer to precise to “HARQ uplink retransmission at the UE transmitter **based on PUSCH decoding results** can be enabled/disable**d**, but HARQ processes remain configured; |
| Thales | Options 1, 2 and 3 |  |  |
| LG | Option 2,  Option 3 | Option 1 | For Option 1, it would be used to solve the HARQ stalling. However, the HARQ stalling problem would not hanppen by the network implementation. |
| CATT | Options 2 and 3 |  |  |
| Nokia | Option1/2/3 |  | As a complete suggestions in TR, we think the LCP impact should be capatured for UL as well. E.g. The LCP impact caused by disabling the HARQ uplink retransmission configuration and its impact on UE's uplink transmission should be discussed. |
| Ericsson |  | 1, 2, 3 | It is NOT about disabling HARQ retransmissions, it is about reusing the HARQ process IDs before a HARQ RTT has passed. This shall obviously be under network control. |
| Qualcomm | All options 1, 2 and 3 | none | Same as DL HARQ process. Additionally LCP impact can be discussed.  However, similar to blind retransmission in DL HARQ process, we can consider if UE can also support the case what Ericsson raised, i.e., the early retransmission grant without waiting RTT. |
| Lenovo | All | None | Agree with Nokia and Qualcomm that LCP impact should be discussed. |
| Apple | Options 1/2/3 |  |  |
| OPPO | Option 1/2/3 |  |  |
| Xiaomi | All | None |  |
| Panasonic | Option 1, 2 and 3 | None | We would like to clarify whether we consider “enabling/disabling” HARQ feedback per LCH in a semi-static manner. |
| Huawei | Option 1  Option 2  Option 3 | None | For Option 1, we prefer to clarify that the disabled retransmission does not impact slot aggregation (same reason as in Q3.1). |
| NEC | Option 1,2,3 |  |  |
| Samsung | Agree |  | Agree with all 3 statements above. |
| Vodafone | All three options |  | All three options are useful and should be at operator’s disposal |
| Intel | Option 1,2,3 |  |  |
| Sequans | All but |  | “enable/disable HARQ uplink retransmission” is still unclear (see question 3.1) |

**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?**

|  |  |  |
| --- | --- | --- |
| **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 |  |
| Nomor Research | Agree | HARQ uplink retransmissions based on PUSCH decoding results can be enabled/disabled in Rel-17 NTN. |
| Thales | Agree |  |
| LG | Disagree | RAN1 can refer the RAN2 decision |
| CATT | Agree |  |
| Nokia | Disagree | Enable/Disable HARQ uplink retransmission at the UE transmitter is gNB’s scheduling behaviour which is up to NW implementation. We don’t see any RAN1 impact which should be metioned. |
| Ericsson | Disagree | We shall send an LS to RAN1 but we shall ask for feasibility for the UE receive grants and assignments for a specific HARQ process ID for consecutive PUSCH/PDSCH allocations. |
| Qualcomm | Agree | Ok to send LS to RAN1. |
| Loon, Google | Agree |  |
| Lenovo | Agree | We should notify RAN1 with the agreements. |
| Apple | Agree | Different parameters may be used for HARQ processes with or without retransmissions which has RAN1 impacts. |
| OPPO | Disagree | We don’t see any immediate RAN1 impact. If any, RAN1 can also refer to the RAN2 agreements. |
| Xiaomi | Agree |  |
| Panasonic | No strong view |  |
| Huawei | Agree |  |
| NEC | Agree |  |
| Samsung | Agree | Keeping RAN1 informed is a good idea. |
| Vodafone | Agree |  |
| Intel | Agree |  |

## 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);**

|  |  |  |
| --- | --- | --- |
| **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 |
| Nomor Research | Option 2 | Current specification [3GPP TS 38.321] states: “*drx-HARQ-RTT-TimerDL*: the minimum duration before a DL assignment for HARQ retransmission is expected by the MAC entity” or “*drx-HARQ-RTT-TimerUL*: the minimum duration before a UL HARQ retransmission grant is expected by the MAC entity” AND “start the *drx-HARQ-RTT-TimerDL* for the corresponding HARQ process in the first symbol after the end of the corresponding transmission carrying the DL HARQ feedback” or “start the *drx-HARQ-RTT-TimerUL* for the corresponding HARQ process in the first symbol after the end of the first repetition of the corresponding PUSCH transmission”.  So Option 2, existing values increased by offset of size UE specific RTD, is preferred. Option 3 should not be supported as there are too many scenarios with different delays meaning Option 3 would result in a unclearly large set of values or in a waste of UE power consumption. |
| Thales | Option 2 | An offset of size of UE specific RTD is added for drx-HARQ-RTT-TimerDL and drx-HARQ-RTT-TimerUL |
| LG | Option 3 | The puspose of the offset for drx-HARQ-RTT-TimerDL/UL is to delay a time to start of the drx-HARQ-RTT-TimerDL/UL. In other words, the UE does not monitor the PDCCH before starting the drx-HARQ-RTT-TimerDL/UL.  Considering that the purpose of the drx-HARQ-RTT-TimerDL/UL is that the UE does not monitor the PDCCH while running the drx-HARQ-RTT-TimerDL/UL, the UE behaviour is same even if the drx-HARQ-RTT-TimerDL/UL is extended instend of the introduction of the offset for the drx-HARQ-RTT-TimerDL/UL.  Thus, RAN2 should discuss firstly whether the offset for drx-HARQ-RTT-TimerDL/UL should be introduced or the drx-HARQ-RTT-TimerDL/UL should be extended. |
| CATT | Option 3 | The drx-HARQ-RTT-TimerDL is the minimum duration before a downlink assignment for HARQ retransmission is expected by the MAC entity. HARQ-RTT-TimerUL for the uplink is samilar with drx-HARQ-RTT-TimerDL.  drx-HARQ-RTT-TimerDL and drx-HARQ-RTT-TimerUL may be extended to support NTN, for example:  drx-HARQ-RTT-TimerDLExt INTEGER (0.. 106848),  drx-HARQ-RTT-TimerULExt INTEGER (0.. 106848),  It’s up to network to config the value via drx-HARQ-RTT-TimerDLExt or drx-HARQ-RTT-TimerDL. |
| Nokia | Option 1 | We think both Option1 and Option2 can work efficiently in a simple way. However, as mentioned by SI recommendation: *Offset based solutions for timer adaptations are preferred to support all NTN scenarios*, we think Option1 is more aligned with the recommendation (e.g. similar to offset to start Ra-ResponseWindow and ra-ContentionResolutionTimer). |
| Ericsson | Option 2 | We shall keep the zero value, that is if drx-HARQ-RTT is zero we shall not add an offset to that value. Option 1 and 2 are the same as there is no use of monitoring for retransmission until the drx-RetransmissionTimer is started. |
| Qualcomm | Option 1 | UE would need to monitor PDCCH during this offset. Simplest way is to add offset to the timer same as to ra-ContentioResolutionTimer. But we can discuss whether to apply offset at the start or at the end. |
| Lenovo | Option 1 or 2 | There is no actual difference for Option 1 and 2. We slightly prefer Option 1 as it is simple to implement and aligns with solutions for *Ra-ResponseWindow* and *ra-ContentionResolutionTimer*. |
| Apple | Option 2 | Or Option 1 is also ok. |
| OPPO | Option 1 | Option 1 is simple and easy to implement. |
| Xiaomi | Option 1 | Prefer to use the recommended solution in SI |
| Panasonic | Option 2 | Option 2 and Option 3 both could work. In option 3, drx-HARQ-RTT timer run unnecessary longer which may further increase data latency for retransmission. However in option 2, UE start timer and applied offset based on its RTD which is more efficient compare to option 3. |
| Huawei | Option 2 | Option 2 is simple and workable. With Option 1, it needs to be specified that UE shall not monitor HARQ retransmissions during the offset. Regarding Option 3, since the current timer is measured in symbols, the values may be extended too large. |
| NEC | Option 2 with clarification | We agree with the comments above for supporting option 2, however, the wording of option 2 could be misunderstood with updating the values of the IE. In our understanding, the values of the IE will be kept as it is. gNB will configure an existing value in the value range, UE will then increase the timer value  by the UE specific offset. Following wording is suggested:  **Option 2:  offset is added by UE to the configured timer value from gNB, i.e. duration of the timer is extended by offset.**  Comparing with option 1,  this option requests  less specification update, even though they are effectively the same. |
| Samsung | Option 1 |  |
| Vodafone | Option 1 primerily | from operation perspective, Option 1 is the stable option, the offsets are applied before the timers, and this is assuming that the roundtrip delay is accurately calculated, and the enough time is allocated to ‘listen’ to the ACK/NACK message,  However, if the orbit of the satellite is fluctuating fast and the air interface conditions are changing rapidly then Option 2 could be implements as a backup solution. |
| Intel | Option 1 | This seems to have the least spec impact and align with other timers. |
| Sequans | Option 1 or 2 |  |

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?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Agree/Disagree** | **Additional comments** |
| MediaTek | Agree |  |
| APT | Agree |  |
| Nomor Research | Agree | Applying UE-specific delay minimizes UE power consumption. |
| Thales | Agree | Need to consider UE-gNB RTD = UE specific RTD + Common RTD |
| LG | Disagree | We prefer the common offset broadcasted by network |
| CATT | Agree | drx-HARQ-RTT-TimerUL and drx-HARQ-RTT-TimerDL offset is defined using UE-specific delay as baseline in LEO/GEO. But there may be different ways of implementaion of offset. |
| Nokia | Tentatively Agree | If UE has the pre-compensation capability,we think using the UE-specific delay based offset is reasonable.  Same comments as Q2.5, we want to clarify UE-specific delay in the proposal is from UE to gNB instead of from UE to reference point, because both of them are mentioned in Section2.1.1. Additionally, the offset applied to RTT timers should be two times of UE-specific delay (from gNB to UE). |
| Ericsson | Agree | If the UE autonomously adjust the ***drx-HARQ-RTT-TimerUL* and *drx-HARQ-RTT-TimerDL*** offset, there is a great risk that there will be misalignment between the gNB and the UE. It may be hard for UE implementation if different HARQ processes are using a different offsets.  If the offset is in the order of the RTT, 25.77 ms for 600 km LEO, then there is no real use to have a resolution of a 0 to 56 symbols after that delay. These timers only influence the PDCCH monitoring when HARQ is used and the last TB have been transmitted. |
| Qualcomm | Agree | Following DL time slot (without uplink compensation), UE and gNB should be in the same page. |
| Lenovo | Agree but | The offset can be defined using UE-specific delay but considering transparent mode we need to clearly define “common delay” e.g. whether feeder link delay is included. |
| Apple | Agree but | For UEs without pre-compensation capabilities this we will need the common offset as mentioned by LG above. |
| OPPO | Agree |  |
| Xiaomi | Agree |  |
| Panasonic | Agree |  |
| Huawei | Agree |  |
| NEC | Agree |  |
| Samsung | Agree | We have UL timers for several operations. We can have one parameter or variable that can be applied to the start of timers instead of individually introducing new parameters (e.g., UE-determined offset when an accurate GNSS-based location estimate is available and the network-specified offset when an accurate GNSS-based location estimate is unavailable). |
| Vodafone | Agree | See our comments above |
| Intel | Agree |  |
| Sequans | Agree but | Need to take into account full RTD (i.e. add common delay) |

### 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.**

|  |  |  |
| --- | --- | --- |
| **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 |  |
| Nomor Research | Agree | Support of blind retransmission in NTN should not be precluded. We wonder, whether it is not possible to start drxRetransmissionTimerDL/ UL directly for blind retransmissions. |
| Thales | Agree | Need to guarantee that neither drx-HARQ-RTT-TimerDL nor drx-HARQ-RTT-TimerUL will start, if HARQ feedback is disabled for the corresponding HARQ process; otherwise UE might monitor the PDCCH for retransmission opportunities that never will happen |
| LG | Agree | For the reception of the blind retransmission, the drx-RetransmissionTimerDL should be started even if the drx-HARQ-RTT-TimerDL is not started for disabling HARQ feedback. |
| CATT | Agree | If HARQ feedback is disabled, drx-HARQ-RTT-TimerDL and drx-HARQ-RTT-TimerUL are not started for both LEO and GEO scenarios. |
| Nokia | Agree with comments | We think blind retransmission is needed to lower the residual BLER as capatured in RAN2 recommenstion in TR.  *• Multiple transmission of the same TB to lower residual BLER should also be configured.*  How to enable UE power saving during blind retransmission phase can be discussed further.  Furthermore, any particular reason why the ‘for both LEO and GEO scenarios’ is explicitly stated, instead of just ‘NTN’? It just reads like HAPS are excluded. |
| Ericsson | Disagree | We agree to first part “**If HARQ feedback is disabled, *drx-HARQ-RTT-TimerDL* and *drx-HARQ-RTT-TimerUL* are not started for both LEO and GEO scenarios.**”  The second part is not needed, we may discuss that and come to an agreement later. |
| Qualcomm | Disagree | To minimize specification change, both HARQ RTT timer and DRX retransmission timer can be set to zero by network. This simply means they start and expire immediately, i.e., not used. |
| Lenovo | Agree | For the first part, we agree to state this although it can be implemented by NW. For the FFS part, UE power consumption may be considered for blind retransmission. |
| Apple | Agree |  |
| OPPO | Agree |  |
| Xiaomi | Disagree | For blind retransmission, drx-HARQ-RTT-TimerDL and drx-HARQ-RTT-TimerUL can be used not only for triggering drx-RetransmissionTimerUL/DL, but also for providing sufficient time gap for different retransmission to acquire time diversity. In this sense, we prefer to keep the two timer running, but their value range can be extended. |
| Panasonic | Disagree | If UE doesn’t start HARQ RTT timer, the blind retransmission should be covered by drx-InactivityTimer instead of drx-Retrasnmissiontimer. In this way less specification impact will be less compare to support blind retransmission via drx-RetrasnmissionTimer. |
| Huawei | Agree |  |
| NEC | Agree |  |
| Samsung | Agree | In TR38.821, the issue of unnecessary monitoring of PDCCHs during the DRX operations in the case of HARQ stalling was identified. Please see “Figure 7.2.1.2-3: Unnecessary monitoring of PDCCH and extra delay due to HARQ stalling.” However, we do not see this topic in this document. Can we please add this topic to the discussion list? |
| Vodafone | Agree | If the UL and DL HARQs are disabled, then there is no need for the UE to monitor the Control Channels. This is a waste of UE’s battery life and unnecessary internal procedures. |
| Intel | Agree |  |
| Sequans | Disagree | In general retransmission timer is started at RTT timer expiry, so not starting RTT timer but keep retramission timer FFS seems strange. We should decide the expected behavior first and agree on the best way to implement it. |

# 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