**3GPP TSG-RAN WG4 Meeting #101-bis-e R4-220XXXX**

**Electronic Meeting, 17th – 25th Jan., 2022**

**Agenda item:** 6.13.5.2 & 6.15.5.4

**Source:** Moderator (Xiaomi)

**Title:** Email discussion summary for [101-bis-e][213] NR\_NTN\_solutions\_RRM\_2

**Document for:** Information

# Introduction

The scope of this email discussion contains GNSS-related requirements and UE timing requirements for NR NTN (AI 6.13.5.2 and AI 6.13.5.4). All the submitted TDocs in this agenda were reviewed and the relevant observations and proposals are included in this email discussion. The following topics will be discussed according to the submitted TDocs.

* AI 6.13.5.2 GNSS-related requirements
* AI 6.13.5.4 Timing requirements
* UE specific TA estimation error
* Initial UE transmit timing requirements
* Double correction issue related to combination of open and closed loop TA control
* Gradual timing adjustment requirements
* TA adjustment accuracy requirements

The timeline for 1st and 2nd round email discussions can be referred in TDoc of “**RAN4#101bis-e E-meeting Arrangements and Guidelines**”

In providing comments, companies are encouraged to:

* Be concise
* Provide comments on all topics/sub-topics of interest to them
* Ensure that their comments are inserted in the latest version of the document by checking the folder before uploading
* Use “Track changes” to help identify added comments/changes

# Topic #1: GNSS-related requirements

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2200076 | CATT | Proposal 1: Use a common GNSS accuracy assumption for all RRM requirements.Proposal 2: The issue of RRM impact due to UE Internal Coexistence between GNSS receiver and NR UL transmitter can be suspended until there is conclusion in RF session. If it is fully independent, there is no RRM impact. |
| R4-2200804 | CMCC | Proposal 1: Use a common GNSS accuracy assumption for all RRM requirements. |
| R4-2201142 | OPPO | Proposal 1: Support to use a common GNSS accuracy assumption for all RRM requirementsProposal 2: RRM impact due to UE Internal Coexistence between GNSS receiver and NR UL transmitter could be further discussed based on RF conclusion. |
| R4-2201631 | Huawei | Proposal 1: GNSS accuracy assumption is discussed by case-by-case basis for different RRM requirements.Proposal 2: RAN4 to consider the following options for addressing UE Internal Coexistence between GNSS receiver and NR UL transmitter:- Option 1: Leave it to UE implementation (no or little spec impact)- Option 2: Define interruption or scheduling restriction in RAN4 (no RAN1/2 impact) |

## Open issues summary and Companies views’ collection for 1st round

**Issue 1-1: GNSS accuracy assumption for RRM requirements**

* Option 1: (CATT, CMCC, OPPO)
	+ Use a common GNSS accuracy assumption for all RRM requirements
* Option 2: (Huawei)
	+ GNSS accuracy assumption is discussed by case-by-case basis for different RRM requirements.
* Recommended WF
	+ Companies are encouraged to provide their views on this issue.

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| **Company** | **Comments** |
| QC | Either option is okay, but to be honest, we do not think this needs to be discussed unless there is a specific requirement that requires a decision on this issue. |
| Ericsson | We prefer option 1, but it is not a strong position. We are prepared to analyze cases. |
| Apple | Option 1 is preferred. |
| Xiaomi | Prefer option 2, even the common GNSS module is used, UE may use different accuracy requirement for different RRM requirement. |

**Issue 1-2: RRM impact due to UE Internal Coexistence between GNSS receiver and NR UL transmitter**

* Option 1: (CATT, OPPO)
	+ Postpone the discussion until RF session has the conclusion.
* Option 2: (Huawei)
	+ RAN4 to consider the following options for addressing UE Internal Coexistence between GNSS receiver and NR UL transmitter:
		- Option 1: Leave it to UE implementation (no or little spec impact)
		- Option 2: Define interruption or scheduling restriction in RAN4 (no RAN1/2 impact)
* Recommended WF
	+ Companies are encouraged to provide their views on this issue.

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| **Company** | **Comments** |
| QC | Option 1. RF session should first assess the impact of NR UL transmission on GNSS receiver in terms of accuracy, frequency, etc. Depending on the analysis, detailed solution can be different. |
| Ericsson | Option 1 is fine. |
| Apple | Option 1. |
| Xiaomi | Option 1. |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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|  | **Status summary**  |
| **Sub-topic #1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

*Note: The tdoc decisions shall be provided in Section 3 and this table is optional in case moderators would like to provide additional information.*

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| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

# Topic #2: UE timing requirements

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2200078 | CATT | **Proposal 1: Do not define the update periodicity for UE specific TA estimation.****Proposal 2: Do not define UE behaviour related to updating rate for UE specific TA estimation.****Proposal 3: Do not specify UE behaviour on UE specific TA updating before applying TA adjustment.****Proposal 4: The [29]\*64\*Tc and [24]\*64\*Tc requirements are relaxed unnecessary, and should be reduced suitably. If the same additional values are used, 26\*64\*Tc and 22\*64\*Tc can be defined for SSB 15kHz/uplink 30kHz and SSB 30kHz/uplink 30kHz****Proposal 5: The gradual timing adjustment requirements for TN UE can be reused for NTN UE.****Proposal 6: The test of gradual timing adjustment requirements may be done only on GEO network.****Proposal 7: UE position and satellite position estimation error should NOT be accounted for TA adjustment accuracy requirement.****Proposal 8: Reuse the existing timing advance adjustment accuracy requirements defined in TS 38.133.****Proposal 9: The test of TA adjustment accuracy requirements may be done only on GEO network.** |
| R4-2200297 | Apple | ***Proposal 1:******No need to specify the update periodicity for UE specific TA estimation.******No need to define UE behaviour related to updating rate for UE specific TA estimation.******No need to specify UE behaviour on UE specific TA updating before applying TA adjustment.******Proposal 2: The principle for gradual timing adjustment requirement is:**** + ***Relax the requirement accordingly to accommodate the timing change/drift, i.e. updating Tq, Tp, and/or the rate***
	+ ***NTN UE is required to adjust its UL timing towards updated UE specific TA and DL timing gradually, according to minimum and maximum aggregate adjustment rate requirements***
	+ ***the design principle for Tq/Tp is:***

***, and*** ***Tq\_NTN= Tp\_NTN******Proposal 3: UE performs timing adjustment with combining downlink reception timing drifting and UE specific TA change as one adjustment.*** ***Proposal 4: we support either option of followings:******Option 1: RAN4 to define different gradual timing adjustment requirements for different NTN topologies, e.g., GEO, LEO and FFS on MEO.******Option 2: RAN4 to define the same gradual timing adjustment requirements for different NTN topologies, and the requirement is specified based on the worst case considering the largest delay variation.******Proposal 5: The maximum delay variation should be considered in the gradual timing adjustment requirement in NTN, i.e., up to +/- 40 µs/sec for LEO in TR38.821.*** ***Proposal 6: If proposal 5 cannot be concluded in RAN4, RAN4 shall send LS to RAN1 to confirm the maximum delay variation.******Proposal 7: No need to consider the feeder link time drift in the gradual timing adjustment requirement in NTN.******Proposal 8: If separate gradual timing adjustment requirements are defined for different NTN topologies, the existing TN gradual timing adjustment requirement can be applied for GEO.******Proposal 9: For LEO (if separated requirement specified for different NTN topologies) or for general gradual timing adjustment requirement (if same requirement specified for different NTN topologies),******1) The maximum amount of the magnitude of the timing change in one adjustment shall be Tq\_NTN.******2) The minimum aggregate adjustment rate shall be Tp\_NTN per 100ms.******3) The maximum aggregate adjustment rate shall be Tq\_NTN per 20 ms.***

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| *Frequency Range* | *SCS of uplink signals (kHz)* | *Tq\_NTN*  | *Tp\_NTN* |
| ***1*** | ***15*** | ***29.5\*64\*Tc*** | ***29.5\*64\*Tc*** |
|  | ***30*** | ***29.5\*64\*Tc*** | ***29.5\*64\*Tc*** |
|  | ***60*** | ***27.5\*64\*Tc*** | ***27.5\*64\*Tc*** |
| ***NOTE: Tc is the basic timing unit defined in TS 38.211***  |

***Proposal 10: UE position and satellite position estimation error should NOT be accounted for TA adjustment accuracy requirement.******Proposal 11: in RRC connected mode, the legacy NR TA adjustment accuracy requirement in TS38.133 could be reused for NTN case.******Proposal 12:*** ***RAN4 to define a requirement to address double-correction issue based on the framework of gradual timing adjustment accuracy requirement, e.g., the requirement regulates the maximum amount of UE specific TA change of shot adjustment due to UE position change, the minimum and maximum aggregate adjustment rates.*** ***Such requirement could be under the framework of legacy NTN gradual timing adjustment requirement with some additional clarification.******Proposal 13:*** ***The gradual timing requirement to address the double correction issue could be based on either of the following options:******Option 1: when open-loop TA is updated, UE to reset the close-loop TA for Tx timing reference point, or******Option 2: when open-loop TA is updated, UE to slow down the gradual timing adjustment but retain the previous close-loop TA for Tx timing reference point*** |
| R4-2200421 | Qualcomm Incorporated | Observations and Proposals are summarized below:**Reference point for UE UL timing accuracy measurement****Proposal 1**: A time reference for the UL transmit timing requirement is the downlink timing of the reference cell minus (N\_TA + N\_{TA,UE-specific} +N\_{TA,common} + N\_{TA,offset}) x T\_c where* Reference timing of downlink is the DL slot corresponding to UL slot index where UE transmits the UL signal/channel.
* Reference timing of N\_{TA,UE-specific} is
	+ for S3, the slot when the UL transmission is supposed to arrive at the target satellite based on provided valid ephemeris information (no error in the provided ephemeris information will account for UE error) and a propagation model more accurate than a reference propagation model (gravity model)
	+ for S4, the slot when the DL transmission corresponding to the reference timing of downlink is supposed to arrive at the target satellite based on actual received time of the slot and provided valid ephemeris information (no error in the provided ephemeris information will account for UE error) and a propagation model more accurate than a reference propagation model (gravity model)
	+ An independent/separate UE requirement on propagation model will be specified. The requirement on UE propagation model should be more accurate than a reference propagation model (gravity model)
* Reference timing for N\_{TA,common}, F3+F4, is derived according to N\_{TA, common} related parameters broadcasted within a validity duration.
* Note that downlink frame boundary should also be adjusted according to open-loop TA control related parameters provided by serving cell.

**TA Adjustment Accuracy****Proposal 2**: NTN TA adjustment accuracy requirement should be the same as the current TA adjustment requirements with the following modifications:* UE autonomous TA adjustment due to updates of UE position estimation, satellite position prediction, and feeder link time drift shall be excluded from the definition of TA adjustment error in response to TAC, i.e. “a relative accuracy to the signalled timing advance value compared to the timing of preceding uplink transmission” shall be modified to not include UE autonomous TA update due to satellite position update and N\_{TA,common} update.
* To resolve the uncertainty on the amount of additional TA adjustment due to UE position estimation, TA adjustment error margin shall be extended by [10]% of the effective UE position estimation error that is assumed for the derivation of UE initial transmission timing error (50m)
* The requirement applies only to a stationary UE.

**Gradual Timing Adjustment and Double Correction****Proposal 3**: RAN4 to down select one between the following two options.* Option 1) replace gradual timing adjustment requirement with NTN UE initial timing accuracy requirement, i.e. NTN UE initial timing accuracy requirement applies to all UL transmissions. And add a margin to the NTN UE initial timing accuracy requirement for UL transmissions not the first transmission in a DRX cycle or DRX is not in use. The margin can be, e.g. [10]% of the effective UE position estimation error that is assumed for the derivation of UE initial transmission timing error (50m).
* Option 2) introduce the following requirement and values of x1, x2, x3, x4, T1 and T2 are FFS:
	+ In connected mode , when UE specific TA calculated based on the UE location corresponds to the last applied UE specific TA differs from the UE specific TA calculated based on most recent GNSS fix by more than x1 , i.e., |TA\_ue(GNSS\_f, sat\_current)-TA\_ue(GNSS\_c, sat\_current)|>x1, where GNSS\_f is the most recent GNSS fix, GNSS\_c is the UE location corresponding to the last applied UE specific TA, and sat\_current is the current satellite location, UE is required to adjust the UE location when calculating the UE specific TA such that the applied UE-specific TA is closer to the TA calculated using the most recent GNSS fix than using GNSS\_c. The adjustment made to UE specific TA due to UE location adjustments shall satisfy the following conditions:
		- the maximum amount of UE specific TA change of one adjustment due to UE location update shall be y, i.e, |TA\_ue\_applied-TA\_ue(GNSS\_c, sat\_current)|<x2.
		- the minimum aggregate adjustment rate shall be x3 per T1 seconds.
		- the maximum aggregate adjustment rate shall be x4 per T2 seconds.
 |
| R4-2200525 | Intel Corporation | **Proposal 1: Capture the description in TS38.133: The UE shall have capability to follow the frame timing change of the reference cell and to correctly estimate and update the UE specific TA value in every certain periodicity, based on its GNSS positions and satellite ephemeris information in connected state.****Proposal 2: RAN4 is to define a requirement based on the framework of gradual timing adjustment accuracy requirement, e.g. the requirement regulates the maximum amount of UE specific TA change of shot adjustment due to UE position change, the minimum and maximum aggregate adjustment rates.****Proposal 3: Specify a set of stand-alone requirements where an NTN UE is required to adjust its UL timing towards updated UE specific TA gradually, according to minimum and maximum aggregate adjustment rate requirements.** |
| R4-2200565 | LG Electronics Inc. | In this contribution, we provide our views on timing requirement for NTN, and we propose * ***Proposal 1***: RAN4 to replace gradual timing adjustment requirement with NTN UE initial timing accuracy requirement for double correction issue as Option 1.
* ***Proposal 2***: RAN4 to define the following UE behavior for UE specific TA updating to avoid double correction issue.
	+ The UE specific TA or open loop TA should be updated at least before uplink transmission (applying TA command) slot.
* ***Proposal 3***: Reuse existing TA adjustment accuracy under the condition of updating UE specific TA or open loop TA before uplink transmission (applying TA command).
 |
| R4-2200680 | Xiaomi | **Proposal 1: RAN4 is not to define update rate for UE specific TA estimation.****Proposal 2: RAN4 is not to define UE behavior on updating rate for UE specific TA estimation.****Proposal 3: RAN4 is not to define UE behavior on UE specific TA updating before applying TA adjustment.****Proposal 4: RAN4 is to define one single set of gradual timing adjustment requirements to incorporate the legacy downlink timing drift and UE specific TA change.****Proposal 5: UE performs timing adjustment with combining downlink reception timing drifting and UE specific TA change as one adjustment.****Proposal 6: The feeder link timing drift should not be considered in gradual timing adjustment requirements.****Proposal 7: The maximum delay variation for the round trip delay should not be considered in the gradual timing adjustment requirement in NTN.****Proposal 8: RAN4 to define the same gradual timing adjustment requirements for different NTN topologies, e.g. GEO, MEO, LEO.****Proposal 9: The gradual timing adjustment requirements for NR NTN UE are specified as follows:****1) The maximum amount of the magnitude of the timing change in one adjustment shall be Tq\_NTN = 13.5Ts.****2) The minimum aggregate adjustment rate shall be Tp\_NTN = 13.5Ts per second.****3) The maximum aggregate adjustment rate shall be Tq\_NTN = 13.5Ts per 200 ms.****Where the maximum autonomous time adjustment step Tq\_NTN and the aggregate adjustment rate Tp\_NTN are specified in Table 1**Table 1: Tq Maximum Autonomous Time Adjustment Step and Tp Minimum Aggregate Adjustment rate

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| --- | --- | --- | --- |
| Frequency Range | SCS of uplink signals (kHz) | Tq\_NTN | Tp\_NTN |
| **1** | **15** | **13.5\*64\*Tc** | **13.5\*64\*Tc** |
|  | **30** | **13.5\*64\*Tc** | **13.5\*64\*Tc** |
|  | **60** | **N.A** | **N.A** |
| **NOTE: Tc is the basic timing unit defined in TS 38.211** |

**Proposal 10: The UE specific TA estimation error should not be accounted in the TA adjustment accuracy requirement.****Proposal 11: The legacy NR TA adjustment accuracy requirements defined in TS 38.133 can be reused for NTN scenario.****Proposal 12: The timing error due to “double-correction” should be accounted in gradual timing adjustment requirement.** |
| R4-2200681 | Xiaomi | DraftCR on timing requirements for NR NTN |
| R4-2200738 | ZTE | **Proposal 1: No need to define the update periodicity for UE specific TA estimation.****Proposal 2: No need to define UE behaviour on updating rate for UE specific TA estimation.****Proposal 3: No need to specify UE behaviour on UE specific TA updating before applying TA adjustment.****Proposal 4: UE position and satellite position estimation error should NOT be accounted for TA adjustment accuracy requirement.****Proposal 5: Reuse the existing timing advance adjustment accuracy requirements defined in TS 38.133.****Proposal 6: Define the same gradual timing adjustment requirements for different NTN topologies.**  |
| R4-2200805 | CMCC | In this contribution, we discuss the NTN timing requirements and provide our proposals. The proposals are:***Proposal 1: Not to define UE specific TA estimation/updating related UE behavior and requirements, as long as UE can meet the timing requirements.******Proposal 2:*** ***The reference timing for the UE transmit timing control requirement shall be the downlink timing of the reference cell minus (NTA+NTA,UE-specific+NTA,common+NTA,offset) ×Tc**** ***Reuse the RAN1 definition of NTA,UE-specific and NTA,common for RAN4 requirement***
	+ ***The NTA,UE-specific and NTA,common should be ideal value, no estimation or calculation error will be included.***
	+ ***Reference timing for NTA,UE-specific and NTA,common is the slot when UL transmission is supposed to arrive at the target satellite based on true satellite position.***

***Proposal 3:*** ***The reference timing for the gradual timing adjustment requirement shall be the downlink timing of the reference cell minus (NTA+NTA,UE-specific+NTA,common+NTA,offset) ×Tc**** ***Reuse the RAN1 definition of NTA,UE-specific and NTA,common for RAN4 requirement***
	+ ***The NTA,UE-specific and NTA,common should be ideal value, no estimation or calculation error will be included.***
	+ ***Reference timing for NTA,UE-specific and NTA,common is the slot when UL transmission is supposed to arrive at the target satellite based on true satellite position.***

***Proposal 4:******There are two alternatives for defining gradual timing adjustment requirement and addressing the “double correction issue”:**** ***Alt 1: Relax the requirement accordingly to accommodate the timing change/drift, i.e. updating Tq, Tp, and/or the rate.***
* ***Alt 2: Replace the gradual timing adjustment requirement by UE specific TA requirement, limiting the error between the subsequent UL transmissions and reference timing within Te\_NTN.***

***Proposal 5:**** ***For GEO topology, the gradual timing adjustment requirement:***
* ***the maximum delay variation for the round trip delay should be considered for Tq\_NTN***
* ***the maximum propagation delay variation due to UE movement should be considered for Tq\_NTN***
* ***the current requirement for Tp can be reused for Tp\_NTN***
* ***X=1000ms***
* ***Y=200ms***

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| --- | --- | --- | --- |
| *Frequency Range* | *SCS of uplink signals (kHz)* | *Tq\_NTN* | *Tp\_NTN* |
| ***1*** | ***15*** | ***9\*64\*Tc*** | ***5.5\*64\*Tc*** |
|  | ***30*** | ***9\*64\*Tc*** | ***5.5\*64\*Tc*** |
|  | ***60*** | ***9\*64\*Tc*** | ***5.5\*64\*Tc*** |
| ***NOTE: Tc is the basic timing unit defined in TS 38.211*** |

* ***For LEO topology, the gradual timing adjustment requirement:***
* ***the maximum delay variation for the round trip delay should be considered for Tq\_NTN***
* ***the maximum propagation delay variation due to UE movement should be considered for Tq\_NTN***
* ***Y=200/N ms***

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| --- | --- | --- | --- |
| *Frequency Range* | *SCS of uplink signals (kHz)* | *Tq\_NTN* | *Tp\_NTN* |
| ***1*** | ***15*** | ***[255/N]\*64\*Tc*** | ***[Z1]\*64\*Tc*** |
|  | ***30*** | ***[255/N]\*64\*Tc*** | ***[Z2]\*64\*Tc*** |
|  | ***60*** | ***[255/N]\*64\*Tc*** | ***[Z3]\*64\*Tc*** |
| ***NOTE: Tc is the basic timing unit defined in TS 38.211*** |

* ***For all kinds of NTN topologies, the common gradual timing adjustment requirement:***
* ***Tq\_NTN is calculated with the assumption of LEO topology***
	+ ***the maximum delay variation for the round trip delay should be considered***
	+ ***the maximum propagation delay variation due to UE movement should be considered***
* ***Tp\_NTN is calculated with the assumption of GEO topology***
* ***X=1000ms***
* ***Y=200/N ms***

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| --- | --- | --- | --- |
| *Frequency Range* | *SCS of uplink signals (kHz)* | *Tq\_NTN* | *Tp\_NTN* |
| ***1*** | ***15*** | ***[255/N]\*64\*Tc*** | ***5.5\*64\*Tc*** |
|  | ***30*** | ***[255/N]\*64\*Tc*** | ***5.5\*64\*Tc*** |
|  | ***60*** | ***[255/N]\*64\*Tc*** | ***5.5\*64\*Tc*** |
| ***NOTE: Tc is the basic timing unit defined in TS 38.211*** |

***Proposal 6: UE position and satellite position estimation error should NOT be accounted for TA adjustment accuracy requirement.******Proposal 7: Reuse the existing timing advance adjustment accuracy requirements defined in TS 38.133.******Proposal 8: Use GEO topology as the assumption during TA adjustment accuracy requirement tests.*** |
| R4-2200931 | MediaTek inc. | ***Observation 1****: There is fundamental difference between the NTN timing drift and TN gradual timing adjustment. The main part of NTN DL timing change is predictable and can be compensated via UE specific TA while the TN DL timing change is unpredictable because BS location is unknown to the UE.****Observation 2****: If the gradual timing adjustment rate is dramatically increased based on the NTN timing drift, then the timing adjustment doesn’t seem gradual, and it may cause reception problem at the satellite side if UE doesn’t pre-compensate the timing drifting in the right direction.****Proposal 1:*** *For NTN gradual timing adjustment requirement, the timing reference should account for the UE autonomous TA adjustment, i.e. reuse the timing reference as used in Te\_NTN requirement* |
| R4-2201160 | OPPO | **Proposal 1: Do not define the update periodicity or UE behaviour for UE specific TA estimation.** **Proposal 2: Do not** **specify** **UE behaviour to update UE specific TA before applying TA adjustment.****Proposal 3: Replace gradual timing adjustment requirements with NTN UE initial timing accuracy requirement and do not define separate gradual timing adjustment requirements.** **Proposal 4: Reuse the existing TA adjustment accuracy requirements** |
| R4-2201445 | Nokia, Nokia Shanghai Bell | In this contribution the following observation and proposal have been made:**Observation 1: If TAC is generated to fix a temporary deviation in the UE transmission timing, when UE updates their autonomous components on the timing advance formula, there may be an overcompensation of the timing advance, generating a similar deviation on the opposite direction (Figure 1).****Observation 2: If TAC is generated to introduce an offset in UE timing due to gNB optimizations, the TAC should be applied regardless of UE accuracy for timing estimation.****Observation 3: Discontinuities on the Common TA function have a similar effect as Time Advance Commands, but are problematic to handle by the UE, because Common TA updates are created at the gNB at time instants unknown to the UE and the respective time of application would be unclear to the UE as well.****Observation 4: Relying on gradual timing adjustment for the UE updating of Common TA may lead to discontinuities in the UE transmit timing due to the errors from applying the tracking model and the large delay to the gNB.****Observation 5: Operation of closed loop and open loop TA control in RRC connected state needs careful design to avoid instability due to erroneous calculation of the UE-specific TA value by the UE.****Observation 6: Solving the issues related to combining open and closed loop TA control must be under the control and responsibility of the gNB and needs further specified solutions.** **Proposal 1: The solutions to resolve the issue on combination of open and closed loop TA control should not be left up to the UE implementation only and further study and specification of solutions involving the gNB is needed.****Proposal 2: RAN4 sends an LS to RAN1 to clarify that stability of the TA control mechanism cannot be guaranteed by RAN4 specifications and dedicated solutions must be specified in RAN1.****Proposal 3: RAN4 evaluates whether the existing UL timing requirements are sufficient or need to be refined.****Observation 7: In order to guarantee TA update loop stability, two operation states for TAC update are needed.** |
| R4-2201493 | Nokia, Nokia Shanghai Bell | **LS on Timing Advance control for Rel-17 NTN RRM** |
| R4-2201585 | Ericsson | **Observation 1: The closed loop terms already have requirements in existing legacy specification, TS 38.133. Proposal 1: Keep existing gradual timing adjustment requirements for the closed loop terms .****Observation 2: The best we can do is to put limits based on the characteristics of at least the UE GNSS positioning accuracy part, for .****Proposal 2: All adjustments made to the UE uplink timing, for shall follow these rules:****1) The UE GNSS position accuracy is 50 meters from true position.****2) The maximum amount UE GNSS position update rate corresponds to a UE speed < 500 km/h.****3) The maximum amount of deviation from true displacement between UE GNSS position updates < , where is time between UE GNSS position updates.** **Proposal 3: The values of k1 and k2 are FFS.** |
| R4-2201586 | Ericsson | Reply LS to RAN1: LS on NTN UL time and frequency synchronization requirements (Timing) |
| R4-2201587 | Ericsson | Reply LS to RAN1: LS on open loop closed loop dual correction of timing |
| R4-2201610 | Huawei, Hisilicon | ***Proposal 1: The UE behaviour on UE specific TA estimation can be taken into account when defining gradual timing adjustment requirements, and there is no need to specify UE behaviour requirements for UE specific TA estimation separately.******Proposal 2: For GEO scenario, the UE performs autonomous timing adjustment according to the downlink timing drift and the update of UE specific TA, where the common TA is assumed to be a fixed value.******Proposal 3: For LEO scenario, the UE performs autonomous timing adjustment according to*** ***the downlink timing drift, the update of UE specific TA and the common TA drift.******Proposal 4: It is suggested that the gradual timing adjustment requirements is tested when the common TA is assumed to be a fixed value, i.e. GEO scenario.******Proposal 5: It is suggested to define the gradual timing adjustment requirements according to the propagation delay drift rate, i.e. the maximum aggregate adjustment rate need to be aligned with the propagation delay drift rate.**** ***For GEO, the propagation delay drift rate equals to the serving link delay drift rate.***
* ***For LEO, the propagation delay drift rate includes the feeder link delay drift rate and the serving link delay drift rate.***

***Proposal 6: It is suggested to consider the values of Tq in Table 3 when defining the gradual timing adjustment requirements for LEO based NTN network.******Proposal 7: It is suggested to consider the values of Tq in Table 4 when defining the gradual timing adjustment requirements for GEO based NTN network.******Proposal 8: It is suggested that the existing TA adjustment accuracy requirements for TN network can be applied for NTN network.*** |

## Open issues summary and Companies views’ collection for 1st round

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### UE specific TA estimation error

**Issue 2-1-1: Whether to define the update periodicity for UE specific TA estimation?**

* Option 1: (CATT, Apple, Xiaomi, ZTE, CMCC, OPPO)
	+ No
* Recommended WF
	+ RAN4 not to define the update periodicity for UE specific TA estimation

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| **Company** | **Comments** |
| QC | What is the significance of Option 1? Anyway, UE specific TA estimation frequency will be indirectly regulated by requirement spec, i.e. in order to meet requirements, UE will have to update UE specific TA at a certain frequency. If the question here is whether and how to define the frequency, we don’t think we should. But, in any case, we don’t think we need any explicit agreement on this. This high-level discussion/agreement (if made) will just create unnecessary confusion later. |
| Ericsson | WF is fine, in so far that we do not have to define specific frequency, but we might need some form of requirement which puts timing accuracy requirements on UE specific TA estimation, if and when UE has something to send on UE TX UL. One example is the dual compensation issue. |
| Apple | Agree with recommended WF, as we discussed in our paper, no need to define such periodicity as long as UE can meet the timing requirement. |
| Xiaomi | Support the recommended WF, RAN1 has reached the conclusion on UE behavior related to UE specific TA in RAN1#107e meeting: *is UE self-estimated TA to pre-compensate for the service link delay, which is calculated using the UE position and the serving satellite ephemeris.**How the UE calculates/updates NTA, UE-specific is left to UE implementation.* |

**Issue 2-1-2: Whether to define UE behaviour related to updating rate for UE specific TA estimation?**

* Option 1: (CATT, Apple, Xiaomi, ZTE, CMCC, OPPO)
	+ No.
* Option 1a: (Huawei)
	+ The UE behaviour on UE specific TA estimation can be taken into account when defining gradual timing adjustment requirements, and there is no need to specify UE behaviour requirements for UE specific TA estimation separately.
* Option 2: (Intel)
	+ Capture the description in TS38.133: The UE shall have capability to follow the frame timing change of the reference cell and to correctly estimate and update the UE specific TA value in every certain periodicity, based on its GNSS positions and satellite ephemeris information in connected state.
* Recommended WF
	+ Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | We do not see the significance of Issue 2-1-2, and have the same comment as Issue 2-1-1. This high-level discussion/agreement (if made) will just create unnecessary confusion later. |
| Ericsson | We might need some form of requirement which puts timing accuracy requirements on UE specific TA estimation, if and when UE has something to send on UE TX UL. One example is the dual compensation issue. |
| Apple | Option 1 and same reason as for issue 2-1-1. |
| Xiaomi | Option1, the same comment as issue 2-1-1. |

**Issue 2-1-3: UE behaviour on UE specific TA updating before applying TA adjustment**

* Option 1: (CATT, Apple, Xiaomi, ZTE, OPPO)
	+ Do not specify UE behaviour on UE specific TA updating before applying TA adjustment.
* Option 2: (LGE)
	+ The UE specific TA or open loop TA should be updated at least before uplink transmission (applying TA command) slot.
* Recommended WF
	+ Companies are encouraged to provide the views on this issue.

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| **Company** | **Comments** |
| QC | Although a detailed design is up to UE implementation choice, the spec at least says UE always has to run open loop TA. Depending on UE implementation and circumstances, UE may not update open loop TA before every single UL transmission, however, it shouldn’t be skipped to the point that the requirements can’t be met.RAN4 doesn’t have to specify UE behavior on this because UE behavior is already specified by RAN1 spec and it is in line with Option 2. |
| Ericsson | Option 2. |
| Apple  | Option 1. As long as the timing requirement can be met, there is no need to define anything for UE implementation specific issue. |
| Xiaomi | Option1, the same comment as issue 2-1-1. |

### Initial UE transmit timing error requirements

**Issue 2-2-1: Requirement of initial transmit timing error (Te\_NTN)**

* Option 1: (CATT)
	+ The [29]\*64\*Tc and [24]\*64\*Tc requirements are relaxed unnecessary, and should be reduced suitably. If the same additional values are used, 26\*64\*Tc and 22\*64\*Tc can be defined for SSB 15kHz/uplink 30kHz and SSB 30kHz/uplink 30kHz.
* Option 2: ()
	+ Keep the agreements in RAN4#101e meeting unchanged.

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | SCS of SSB signals (kHz) | SCS of uplink signals (kHz) | Te\_NTN |
| 1 | 15 | 15 | [29]\*64\*Tc |
| 30 | 24\*64\*Tc |
| 60 | N.A |
| 30 | 15 | [24]\*64\*Tc |
| 30 | 22\*64\*Tc |
| 60 | N.A |
| NOTE: Tc is the basic timing unit defined in TS 38.211 |

* Recommended WF
	+ Companies are encouraged to provide the views on this issue.

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| --- | --- |
| **Company** | **Comments** |
| QC | Option 2. There is still a large enough margin within the total budget. |
| Ericsson | We agree with CATT opinion that [29] and [24] is relaxed (compared to Ericsson contribution, for example), but option 2 is fine for us. It is still within bounds. |
| Apple | Retain the last meeting agreement and support option 2. |
| Xiaomi | Option 2 |

**Issue 2-2-2: The reference timing for UE transmit timing.**

* Option 1: (Qualcomm)
	+ A time reference for the UL transmit timing requirement is the downlink timing of the reference cell minus (N\_TA + N\_{TA,UE-specific} +N\_{TA,common} + N\_{TA,offset}) x T\_c where
		- Reference timing of downlink is the DL slot corresponding to UL slot index where UE transmits the UL signal/channel.
		- Reference timing of N\_{TA,UE-specific} is
			* for S3, the slot when the UL transmission is supposed to arrive at the target satellite based on provided valid ephemeris information (no error in the provided ephemeris information will account for UE error) and a propagation model more accurate than a reference propagation model (gravity model)
			* for S4, the slot when the DL transmission corresponding to the reference timing of downlink is supposed to arrive at the target satellite based on actual received time of the slot and provided valid ephemeris information (no error in the provided ephemeris information will account for UE error) and a propagation model more accurate than a reference propagation model (gravity model)
			* An independent/separate UE requirement on propagation model will be specified. The requirement on UE propagation model should be more accurate than a reference propagation model (gravity model)
		- Reference timing for N\_{TA,common}, F3+F4, is derived according to N\_{TA, common} related parameters broadcasted within a validity duration.
		- Note that downlink frame boundary should also be adjusted according to open-loop TA control related parameters provided by serving cell.
* Option 2: (CMCC)
	+ The reference timing for the UE transmit timing control requirement shall be the downlink timing of the reference cell minus (NTA+NTA,UE-specific+NTA,common+NTA,offset) ×Tc
		- Reuse the RAN1 definition of NTA,UE-specific and NTA,common for RAN4 requirement
		- The NTA,UE-specific and NTA,common should be ideal value, no estimation or calculation error will be included.
		- Reference timing for NTA,UE-specific and NTA,common is the slot when UL transmission is supposed to arrive at the target satellite based on true satellite position.
* Option 3: (MTK)
	+ For NTN gradual timing adjustment requirement, the timing reference should account for the UE autonomous TA adjustment, i.e. reuse the timing reference as used in Te\_NTN requirement.
* Recommended WF
	+ The reference timing for the UE transmit timing shall be the downlink timing of the reference cell minus (NTA+NTA,UE-specific+NTA,common+NTA,offset) ×Tc.
	+ Companies are encouraged to provide views on the additional clarification on the reference timing.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | Option 1.Depending on how the reference timing is defined, a measured timing error can deviate from the error that UE can really achieve. In NTN, all parameters change over time. For example, a downlink timing boundary from UE perspective is not fixed, hence, a slot index should also be specified to clearly define the reference downlink timing. Regarding UE specific TA, any error included in satellite Ephemeris should be excluded from UE timing accuracy, and the satellite position shouldn’t be based on a true position. To us, the only option that addresses those aspects and covers all the details is Option 1. |
| Ericsson | Option 2. |
| Apple | Agree with recommended WF. We have one comment on option 2, the reference time is also used by UE to determine if gradual timing adjustment is needed, and we don’t think NTA,UE-specific in this reference time shall be the ideal value because UE side measurement/estimation is involved to derive NTA,UE-specific; but for other three components, NTA, NTA,common, NTA,offset are all indicated by network or predefined in spec and therefore they are ideal values. |
| Xiaomi | Support the recommended WF, regarding the reference timing of NTA,UE-specific, it should be the value based on the valid ephemeris without estimation error.  |

### Double correction issue related to combination of open and closed loop TA control

*RAN4 has reached an agreement that RAN4 defines a requirement to ensure the impact on NTN UE UL timing accuracy due to “double-correction” issue is properly addressed. There are the following two alternatives for further discussion.*

* *Option 1:*
	+ *RAN4 to replace gradual timing adjustment requirement with NTN UE initial timing accuracy requirement, i.e. NTN UE initial timing accuracy requirement applies to all UL transmissions.*
* *Option 2:*
	+ *RAN4 to define a requirement based on the framework of gradual timing adjustment accuracy requirement, e.g. the requirement regulates the maximum amount of UE specific TA change of shot adjustment due to UE position change, the minimum and maximum aggregate adjustment rates.*
	+ *FFS on whether the requirement regulating “double-correction” issue would be a stand-alone requirement*
	+ *FFS on whether and how to incorporate the current gradual timing adjustment defined in 7.1.2.1 of TS38.133*
	+ *FFS on whether and how to incorporate UE specific change due to satellite position change and feeder link delay change*
	+ *FFS on the detailed requirement values and the definition of reference time in terms of UL timing error measurement*

**Issue 2-3-1: Double correction issue related to combination of open and closed loop TA control.**

* Option 1: (Apple, Intel, Xiaomi)
	+ RAN4 to define a requirement to address double-correction issue based on the framework of gradual timing adjustment accuracy requirement, e.g., the requirement regulates the maximum amount of UE specific TA change of shot adjustment due to UE position change, the minimum and maximum aggregate adjustment rates.
	+ Such requirement could be under the framework of legacy NTN gradual timing adjustment requirement with some additional clarification.
* Option 1a: (Apple)
	+ RAN4 to define a requirement to address double-correction issue based on the framework of gradual timing adjustment accuracy requirement, e.g., the requirement regulates the maximum amount of UE specific TA change of shot adjustment due to UE position change, the minimum and maximum aggregate adjustment rates.
	+ Such requirement could be under the framework of legacy NTN gradual timing adjustment requirement with some additional clarification.
	+ The gradual timing requirement to address the double correction issue could be based on either of the following options:
		- Option 1: when open-loop TA is updated, UE to reset the close-loop TA for Tx timing reference point, or
		- Option 2: when open-loop TA is updated, UE to slow down the gradual timing adjustment but retain the previous close-loop TA for Tx timing reference point
* Option 2: (Qualcomm)
	+ RAN4 to down select one between the following two options.
		- Option 1) replace gradual timing adjustment requirement with NTN UE initial timing accuracy requirement, i.e. NTN UE initial timing accuracy requirement applies to all UL transmissions. And add a margin to the NTN UE initial timing accuracy requirement for UL transmissions not the first transmission in a DRX cycle or DRX is not in use. The margin can be, e.g. [10]% of the effective UE position estimation error that is assumed for the derivation of UE initial transmission timing error (50m).
		- Option 2) introduce the following requirement and values of x1, x2, x3, x4, T1 and T2 are FFS:
			* In connected mode , when UE specific TA calculated based on the UE location corresponds to the last applied UE specific TA differs from the UE specific TA calculated based on most recent GNSS fix by more than x1 , i.e., |TA\_ue(GNSS\_f, sat\_current)-TA\_ue(GNSS\_c, sat\_current)|>x1, where GNSS\_f is the most recent GNSS fix, GNSS\_c is the UE location corresponding to the last applied UE specific TA, and sat\_current is the current satellite location, UE is required to adjust the UE location when calculating the UE specific TA such that the applied UE-specific TA is closer to the TA calculated using the most recent GNSS fix than using GNSS\_c. The adjustment made to UE specific TA due to UE location adjustments shall satisfy the following conditions:
			* the maximum amount of UE specific TA change of one adjustment due to UE location update shall be y, i.e, |TA\_ue\_applied-TA\_ue(GNSS\_c, sat\_current)|<x2.
			* the minimum aggregate adjustment rate shall be x3 per T1 seconds.
			* the maximum aggregate adjustment rate shall be x4 per T2 seconds.
* Option 3: (LGE)
	+ RAN4 to replace gradual timing adjustment requirement with NTN UE initial timing accuracy requirement for double correction issue as Option 1.
	+ RAN4 to define the following UE behavior for UE specific TA updating to avoid double correction issue.
		- The UE specific TA or open loop TA should be updated at least before uplink transmission (applying TA command) slot.
* Option 4: (CMCC)
	+ There are two alternatives for defining gradual timing adjustment requirement and addressing the “double correction issue”:
		- Alt 1: Relax the requirement accordingly to accommodate the timing change/drift, i.e. updating Tq, Tp, and/or the rate.
		- Alt 2: Replace the gradual timing adjustment requirement by UE specific TA requirement, limiting the error between the subsequent UL transmissions and reference timing within Te\_NTN.
* Option 5: (Nokia)
	+ The solutions to resolve the issue on combination of open and closed loop TA control should not be left up to the UE implementation only and further study and specification of solutions involving the gNB is needed.
	+ RAN4 sends an LS to RAN1 to clarify that stability of the TA control mechanism cannot be guaranteed by RAN4 specifications and dedicated solutions must be specified in RAN1.
	+ RAN4 evaluates whether the existing UL timing requirements are sufficient or need to be refined.
* Recommended WF
	+ Companies are encouraged to provide the views on this issue.

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| **Company** | **Comments** |
| QC | In a high level, we prefer Opinion 1 from the previous meeting.* *Option 1:*
	+ *RAN4 to replace gradual timing adjustment requirement with NTN UE initial timing accuracy requirement, i.e. NTN UE initial timing accuracy requirement applies to all UL transmissions.*

The option 1 is the most straightforward way for resolving the root cause of the issue. It should be noted that Option 1 doesn’t always require UE to read GNSS fix and update its position before every single UL transmission. It is still up to UE implementation whether and how often its position will be updated as long as the requirement is met. Only when UE moves faster than a certain speed, UE may have to update its position more often. But this is anyway how open loop TA is designed in RAN1 for NTN UEs.All other options, to us, do not seem to resolve the issue but just define another relaxed requirement. |
| Ericsson | Our proposal is related to the gradual timing option, but the position is not strong. We are fine to replace gradual timing adjustment requirement with NTN UE initial timing accuracy requirement, i.e. NTN UE initial timing accuracy requirement applies to all UL transmissions, if that solves the issue at hand. |
| Apple | Option 1. We still think it would be better use gradual timing adjustment framework for this double correction scenario but of course we could add some clarification in spec if the reference timing needs to be modified or condition to trigger/perform gradual timing adjustment could be relaxed. We cannot agree to use initial Tx timing requirement and method for this double correction issue, because in legacy requirement why Te is only used for initial transmission and we rely on gradual timing adjustment for other time period is: we don’t expect UE to adjust timing significantly during active time from slot to slot (so that’s why we have Tp/Tq to control the adjustment step/pace), that also would cause problem to network (imaging that many UEs have big jumps on Tx timing change in the coverage and network has no idea when those UEs would make such big timing change, and therefore that would have quite diverse reception timings at network reception) . |
| Xiaomi | Option 1, we think the framework of gradual timing adjustment requirement can address the double correction issue with some additional clarifications. e.g., the timing error due to double correction can be adjusted according to the minimum amount of timing change in one adjustment and maximum aggregate adjustment rates.If option 2 is used, the Te requirement is applied to every UL transmission occasion which will introduce the new UE behaviour and test case design. |

### Gradual timing adjustment requirements

**Issue 2-4-1: The principle for gradual timing adjustment.**

* Option 1: (Apple)
	+ Relax the requirement accordingly to accommodate the timing change/drift, i.e. updating Tq, Tp, and/or the rate
	+ NTN UE is required to adjust its UL timing towards updated UE specific TA and DL timing gradually, according to minimum and maximum aggregate adjustment rate requirements
	+ the design principle for Tq/Tp is:

**,**

**Where, Tq\_NTN= Tp\_NTN**

* Option 2: (Xiaomi)
	+ RAN4 is to define one single set of gradual timing adjustment requirements to incorporate the legacy downlink timing drift and UE specific TA change.
* Option 3: (Intel)
	+ RAN4 is to define a requirement based on the framework of gradual timing adjustment accuracy requirement, e.g. the requirement regulates the maximum amount of UE specific TA change of shot adjustment due to UE position change, the minimum and maximum aggregate adjustment rates.
	+ Specify a set of stand-alone requirements where an NTN UE is required to adjust its UL timing towards updated UE specific TA gradually, according to minimum and maximum aggregate adjustment rate requirements.
* Option 4: (Huawei)
	+ It is suggested to define the gradual timing adjustment requirements according to the propagation delay drift rate, i.e. the maximum aggregate adjustment rate need to be aligned with the propagation delay drift rate.
		- For GEO, the propagation delay drift rate equals to the serving link delay drift rate.
		- For LEO, the propagation delay drift rate includes the feeder link delay drift rate and the serving link delay drift rate.
* Option 5: (Ericsson)
	+ Keep existing gradual timing adjustment requirements for the closed loop terms NTA+NTA,offset.
	+ The best we can do is to put limits based on the characteristics of at least the UE GNSS positioning accuracy part, for NTA,UE-specific.
	+ All adjustments made to the UE uplink timing, for shall follow these rules:
		- The UE GNSS position accuracy is 50 meters from true position.
		- The maximum amount UE GNSS position update rate corresponds to a UE speed < 500 km/h.
		- The maximum amount of deviation from true displacement between UE GNSS position updates < , where is time between UE GNSS position updates.
			* The values of k1 and k2 are FFS.
* Option 6: (Qualcomm)
	+ Replace gradual timing adjustment requirement with NTN UE initial timing accuracy requirement, i.e. NTN UE initial timing accuracy requirement applies to all UL transmissions. And add a margin to the NTN UE initial timing accuracy requirement for UL transmissions not the first transmission in a DRX cycle or DRX is not in use. The margin can be, e.g. [10]% of the effective UE position estimation error that is assumed for the derivation of UE initial transmission timing error (50m).
* Option 7: (MTK)
	+ For NTN gradual timing adjustment requirement, the timing reference should account for the UE autonomous TA adjustment, i.e. reuse the timing reference as used in Te\_NTN requirement.
* Recommended WF
	+ Companies are encouraged to provide the views on this issue.

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| **Company** | **Comments** |
| QC | Option 6.We do not think a gradual timing adjust requirement is really relevant to NTN scenario. A sudden big downlink timing jump due to blocking is unlikely in NTN. And it will just confuse UE because UE will receive downlink signals at a totally unexpected timing all of sudden. We should keep in mind that NTN UE does not only keep track of downlink reception timing, but also predicts its future arrival timing to determine a reference timing position before applying TA. So RAN4 should not create any unlikely and artificial requirement. |
| Ericsson | Our proposal is related to the gradual timing option, but the position is not strong. We are fine to replace gradual timing adjustment requirement with NTN UE initial timing accuracy requirement, i.e. NTN UE initial timing accuracy requirement applies to all UL transmissions, if that solves the issue at hand.Option 1 is similar to earlier Ericsson proposals and is fine in principle, but does not solve the double correction issue.We support option 2 a single set based on limiting requirement, LEO.We support option 3.We support option 4, if RAN4 decides to have separate LEO, MEO, GEO requirements, even if we prefer not to.Option 6 is also fine. As stated in preamble we are open to any option to resolve dual compensation issue. |
| Apple | Option 1. We don’t want to mix Tp/Tq design with the double correction issue first, even though we support option 2 with some clarification in spec for double correction. Tp/Tq shall be basically designed based on gradual changing factors due to, e.g., moving speed, time drifting, and etc, but not due to instant open loop TA update. So in issue 2-3-1, we propose two methods:* Option 1: when open-loop TA is updated, UE to reset the close-loop TA for Tx timing reference point (i.e., adjust reference timing but not change Tp/Tq), or
* Option 2: when open-loop TA is updated, UE to slow down the gradual timing adjustment but retain the previous close-loop TA for Tx timing reference point (adjust Tp/Tq for double correction case based on the legacy NTN Tp/Tq to give network sufficient time to react to such double correction)
 |
| Xiaomi | Support the first 2 bullet in option 1, regarding the third bullet in option 1, we think the propagation delay variation should not be introduced in gradual timing adjustment requirement. Since in RAN1, the propagation delay variation for feeder link can be pre-compensated by the following calculation.*Using indicated Higher-layer Common TA parameters, if configured, the UE can determine the one-way propagation time ( used for calculation as follows:**where:** *, and*
* *TACommon, TACommonDrift and TACommonDriftVariation are Common TA parameters defined in RAN1#106-bis-e*
* *is the distance between the satellite and the uplink time synchronization reference point divided by the speed of light. DL and UL are frame aligned at the reference point with an offset given by .*
* *is derived by the UE based on to pre-compensate the two-way transmission delay between the uplink time reference point and the satellite.*

For service link, although PVT information or ephemeris information broadcast by the NW are only an instantaneous value, the UE can derive the satellite's position and velocity in real time according to Kepler's law. Thus, the propagation delay variation for service link is not needed. For the UE position change, it depends on the UE speed and GNSS update rate, some margin can be considered for UE position change. |

**Issue 2-4-2: UE behaviour for gradual timing adjustment for NTN UE**

* Option 1: ()
	+ UE performs timing adjustment for downlink reception timing drifting and UE specific TA change separately.
* Option 2: (Apple, Xiaomi)
	+ UE performs timing adjustment with combining downlink reception timing drifting and UE specific TA change as one adjustment.
* Recommended WF
	+ Companies are encouraged to provide the views on this issue.

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| **Company** | **Comments** |
| QC | We do not see a point of discussing this. |
| Ericsson | Option 2. |
| Apple  | Option 2. |
| Xiaomi | Option 2 |

**Issue 2-4-3: Whether define different gradual timing adjustment requirements for different NTN topologies** **e.g. GEO, MEO, LEO.**

* Option 1: (Apple, CMCC)
	+ Yes, RAN4 to define different gradual timing adjustment requirements for different NTN topologies, e.g., GEO, MEO, LEO, etc.
* Option 2: (Apple, Xiaomi, ZTE, CMCC)
	+ No, RAN4 to define the same gradual timing adjustment requirements for different NTN topologies.
* Recommended WF
	+ Companies are encouraged to provide the views on this issue.

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| **Company** | **Comments** |
| QC | We do not see a point of defining gradual timing adjustment. The scenario is artificial and not likely. |
| Ericsson | Option 2 is preferred. Option 1 is possible if that is RAN4 consensus. |
| Apple | We could compromise to Option 2 and in our paper we also propose:Option 2a: The maximum delay variation should be considered in the gradual timing adjustment requirement in NTN, i.e., up to +/- 40 µs/sec for LEO in TR38.821. If it cannot be concluded in RAN4, RAN4 shall send LS to RAN1 to confirm the maximum delay variation. |
| Xiaomi | Support option 2, since there is no need to consider the propagation delay variation for service link and feeder link. |

**Issue 2-4-4: Whether the maximum delay variation for the round trip delay should be considered in the gradual timing adjustment requirement in NTN?**

* Option 1: (Apple, CMCC, Huawei)
	+ Yes
* Option 2: (Xiaomi)
	+ No
* Recommended WF
	+ Companies are encouraged to provide the views on this issue.

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| --- | --- |
| **Company** | **Comments** |
| QC | Although we oppose defining a gradual timing adjustment, Option 1 will just relax the requirement more than necessary. The key, if have to discuss, should be how to define a reference timing for the measurement of the amount of relative timing adjustment. The reference timing can be defined in such a way that the exact amount of timing adjustment to pre-compensate satellite/UE mobility and a drift on feeder link can still be allowed. |
| Ericsson | Option 1, Yes. |
| Apple | Option 1. |
| Xiaomi | Support option 2, the delay variation for service link and feeder link are addressed by RAN1 design and UE implementation. |

**Issue 2-4-5: Whether the feeder link time drift should be considered in the gradual timing adjustment requirement in NTN?**

* Option 1: (CMCC, Huawei)
	+ Yes
* Option 2: (Apple, Xiaomi)
	+ No
* Recommended WF
	+ Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | Same comment as Issue 2-4-4. |
| Ericsson | Option 1, Yes. |
| Apple | Option 2. That part shall be compensated/handled by network, and we don’t want UE to enhance gradual timing adjustment to take care of such feeder link drifting. Even though this feeder link drifting is not considered at Tp/Tq, network could still send close loop TA command or new TA\_common to make timing adjustment at UE when it realized big drifting on feeder link. |
| Xiaomi | Support option 2, the delay variation for feeder link are addressed by RAN1 design. |

**Issue 2-4-6: The gradual timing adjustment requirement**

* Option 1: (CATT)
	+ The gradual timing adjustment requirements for TN UE can be reused for NTN UE.
* Option 2: (Apple)
	+ For LEO (if separated requirement specified for different NTN topologies) or for general gradual timing adjustment requirement (if same requirement specified for different NTN topologies),
		- 1) The maximum amount of the magnitude of the timing change in one adjustment shall be Tq\_NTN.
		- 2) The minimum aggregate adjustment rate shall be Tp\_NTN per 100ms.
		- 3) The maximum aggregate adjustment rate shall be Tq\_NTN per 20 ms.

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | SCS of uplink signals (kHz) | Tq\_NTN for LEO | Tp\_NTN for LEO |
| 1 | 15 | 29.5\*64\*Tc | 29.5\*64\*Tc |
|  | 30 | 29.5\*64\*Tc | 29.5\*64\*Tc |
|  | 60 | 27.5\*64\*Tc | 27.5\*64\*Tc |
| NOTE: Tc is the basic timing unit defined in TS 38.211 |

* Option 3: (Xiaomi)
	+ The gradual timing adjustment requirements for NR NTN UE are specified as follows:
		- 1) The maximum amount of the magnitude of the timing change in one adjustment shall be Tq\_NTN = 13.5Ts.
		- 2) The minimum aggregate adjustment rate shall be Tp\_NTN = 13.5Ts per second.
		- 3) The maximum aggregate adjustment rate shall be Tq\_NTN = 13.5Ts per 200 ms.

Where the maximum autonomous time adjustment step Tq\_NTN and the aggregate adjustment rate Tp\_NTN are specified in Table 1

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | SCS of uplink signals (kHz) | Tq\_NTN | Tp\_NTN |
| 1 | 15 | 13.5\*64\*Tc | 13.5\*64\*Tc |
|  | 30 | 13.5\*64\*Tc | 13.5\*64\*Tc |
|  | 60 | N.A | N.A |
| NOTE: Tc is the basic timing unit defined in TS 38.211 |

* Option 4: (CMCC)
	+ For GEO topology, the gradual timing adjustment requirement:
		- the maximum delay variation for the round trip delay should be considered for Tq\_NTN
		- the maximum propagation delay variation due to UE movement should be considered for Tq\_NTN
		- the current requirement for Tp can be reused for Tp\_NTN
		- X=1000ms
		- Y=200ms

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | SCS of uplink signals (kHz) | Tq\_NTN | Tp\_NTN |
| 1 | 15 | 9\*64\*Tc | 5.5\*64\*Tc |
|  | 30 | 9\*64\*Tc | 5.5\*64\*Tc |
|  | 60 | 9\*64\*Tc | 5.5\*64\*Tc |
| NOTE: Tc is the basic timing unit defined in TS 38.211 |

* + For LEO topology, the gradual timing adjustment requirement:
		- the maximum delay variation for the round trip delay should be considered for Tq\_NTN
		- the maximum propagation delay variation due to UE movement should be considered for Tq\_NTN
		- Y=200/N ms

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | SCS of uplink signals (kHz) | Tq\_NTN | Tp\_NTN |
| 1 | 15 | [255/N]\*64\*Tc | [Z1]\*64\*Tc |
|  | 30 | [255/N]\*64\*Tc | [Z2]\*64\*Tc |
|  | 60 | [255/N]\*64\*Tc | [Z3]\*64\*Tc |
| NOTE: Tc is the basic timing unit defined in TS 38.211 |

* + For all kinds of NTN topologies, the common gradual timing adjustment requirement:
		- Tq\_NTN is calculated with the assumption of LEO topology
			* the maximum delay variation for the round trip delay should be considered
			* the maximum propagation delay variation due to UE movement should be considered
		- Tp\_NTN is calculated with the assumption of GEO topology
		- X=1000ms
		- Y=200/N ms

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | SCS of uplink signals (kHz) | Tq\_NTN | Tp\_NTN |
| 1 | 15 | [255/N]\*64\*Tc | 5.5\*64\*Tc |
|  | 30 | [255/N]\*64\*Tc | 5.5\*64\*Tc |
|  | 60 | [255/N]\*64\*Tc | 5.5\*64\*Tc |
| NOTE: Tc is the basic timing unit defined in TS 38.211 |

* Option 5: (Huawei)
	+ It is suggested to consider the values of Tq in Table 3 when defining the gradual timing adjustment requirements for LEO based NTN network.

**Table 3: Timing drift for LEO based NTN network**

|  |  |
| --- | --- |
| **Parameters** | **Values** |
| Frequency range | FR1 | FR2 |
| UL SCS | 15kHz | 15kHz | 15kHz | 60kHz | 120kHz |
| BWmin | 5MHz | 5MHz | 10MHz | 50MHz | 50MHz |
| Sampling interval | 4Ts | 4Ts | 2Ts | 0.5Ts | 0.5Ts |
| Timing drift due to 0.1ppm frequency error (per 200ms) | 20ns | 20ns | 20ns | 20ns | 20ns |
| Max delay variation (per 200ms) | 8us | 8us | 8us | 8us | 8us |
| Max downlink timing drift(per 200ms) | 8us | 8us | 8us | 8us | 8us |
| Max TA variation per 200ms | 16us | 16us | 16us | 16us | 16us |
| Tq for downlink timing drift | w/o DigRF error | 248Ts | 248Ts | 248Ts | 246.5Ts | 246.5Ts |
| w/ DigRF error | 249.5Ts | 249.5Ts | 249.5Ts | 248Ts | 248Ts |
| Tq for TA variation | w/o DigRF error | 496Ts | 496Ts | 494Ts | 492.5Ts | 492.5Ts |
| w/ DigRF error | 497.5Ts | 497.5Ts | 495.5Ts | 494Ts | 494Ts |
| Tq for combining downlink timing drift and TA variation  | w/o DigRF error | 248Ts | 248Ts | 248Ts | 246.5Ts | 246.5Ts |
| w/ DigRF error | 249.5Ts | 249.5Ts | 249.5Ts | 248Ts | 248Ts |
| Note 1: The time length of Ts equals to 1/30720000 second (≈ 32.55 ns)Note 2: DigRF error is assumed as 1.5Ts. |

* + It is suggested to consider the values of Tq in Table 4 when defining the gradual timing adjustment requirements for GEO based NTN network.

**Table 4: Timing drift for GEO based NTN network**

|  |  |
| --- | --- |
| **Parameters** | Values |
| Frequency range | FR1 | FR2 |
| UL SCS | 15kHz | 15kHz | 15kHz | 60kHz | 120kHz |
| BWmin | 5MHz | 5MHz | 10MHz | 50MHz | 50MHz |
| Sampling interval | 4Ts | 4Ts | 2Ts | 0.5Ts | 0.5Ts |
| Timing drift due to 0.1ppm frequency error (per 200ms) | 20ns | 20ns | 20ns | 20ns | 20ns |
| Max UE speed | 1200 km/h | 1200 km/h | 1200 km/h | 1200 km/h | 1200 km/h |
| Max delay variation (per 200ms) | 222.22 ns | 222.22 ns | 222.22 ns | 222.22 ns | 222.22 ns |
| Max downlink timing drift(per 200ms) | 242.22 ns | 242.22 ns | 242.2 ns | 242.22 ns | 242.22 ns |
| Max TA variation per 200ms | 444.44 ns | 444.44 ns | 444.44 ns | 444.44 ns | 444.44 ns |
| Downlink timing drift | 8Ts | 8Ts | 8Ts | 7.5Ts | 7.5Ts |
| TA variation | 16Ts | 16Ts | 14Ts | 14Ts | 14Ts |
| Tq for combining downlink timing drift and TA variation  | w/o DigRF error | 8Ts | 8Ts | 8Ts | 7.5Ts | 7.5Ts |
| w/ DigRF error | 9.5Ts | 9.5Ts | 9.5Ts | 9Ts | 9Ts |
| Note 1: The time length of Ts equals to 1/30720000 second (≈ 32.55 ns)Note 2: DigRF error is assumed as 1.5Ts. |

* Recommended WF
	+ Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | Same comment as Issue 2-4-4. |
| Ericsson | Regrading option 1, we do not think a complete reuse is possible. Ether the limits or the period has to change or both. This is also related to dual compensation issue outcome.The proposal from Apple, option 2 has used 40 µs/s but latest TR 38.821 v16.1.0 states +/- 93 µs/s. We prefer to keep gradual step requirement limits less than a TA step, if possible.The proposal from Huawei, option 5, has used 40 µs/s but latest TR 38.821 v16.1.0 states +/- 93 µs/s. We prefer to keep gradual step requirement limits less than a TA step, if possible. |
| Apple | Thanks Ericsson for pointing out the updating of TS38.821, based on +/- 93 us/s delay variation, the following analysis is used

|  |  |
| --- | --- |
| **Tq\_NTN for LEO** | FR1 |
| UL SCS  | 15KHz | 30 KHz | 60 KHz |
| Min UL BW in RF spec  | 25PRBs (5MHz) | 11PRBs (5MHz) | 11PRBs (10MHz) |
| UL granularity based on minimum BW | 4Ts | 4Ts | 2Ts |
| (Max delay variation + time drifting)/20ms | 57.2Ts | 57.2Ts | 57.2Ts |
| DigRF error | 1.5Ts | 1.5Ts | 1.5Ts |
| Tq (with 1.5Ts DigRF error) | 61.5Ts | 61.5Ts | 59.5Ts |

In the legacy TN requirement, the gradual timing adjustment could be greater than smallest TA step for some SCS cases. Thus, the option 2 is updated as:* Option 2: (Apple)
	+ For LEO (if separated requirement specified for different NTN topologies) or for general gradual timing adjustment requirement (if same requirement specified for different NTN topologies),
		- 1) The maximum amount of the magnitude of the timing change in one adjustment shall be Tq\_NTN.
		- 2) The minimum aggregate adjustment rate shall be Tp\_NTN per 100ms.
		- 3) The maximum aggregate adjustment rate shall be Tq\_NTN per 20 ms.

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency Range | SCS of uplink signals (kHz) | Tq\_NTN for LEO | Tp\_NTN for LEO |
| 1 | 15 | 61.5\*64\*Tc | 61.5\*64\*Tc |
|  | 30 | 61.5\*64\*Tc | 61.5\*64\*Tc |
|  | 60 | 59.5\*64\*Tc | 59.5\*64\*Tc |
| NOTE: Tc is the basic timing unit defined in TS 38.211 |

 |
| Xiaomi | Option 2, up to the conclusions for other issues. |

### TA adjustment accuracy requirements

**Issue 2-5-1: Whether the UE position and satellite position estimation error should be accounted for TA adjustment accuracy requirement.**

* Option 1: (CATT, Apple, Xiaomi, Qualcomm, ZTE, CMCC)
	+ UE position and satellite position estimation error should NOT be accounted for TA adjustment accuracy requirement.
* Recommended WF
	+ UE position and satellite position estimation error should NOT be accounted for TA adjustment accuracy requirement.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | We skip this and go to Issue 2-5-2 directly. |
| Ericsson | The WF is fine. |
| Apple | Fine with recommended WF. |
| Xiaomi | Support the recommended WF. |

**Issue 2-5-2: TA adjustment accuracy requirement in RRC\_CONNECTED mode**

* Option 1: (CATT, Apple, CMCC, Xiaomi, ZTE, OPPO, Huawei)
	+ The legacy NR TA adjustment accuracy requirements defined in TS 38.133 can be reused for NTN scenario.
* Option 1a: (LGE)
	+ Reuse existing TA adjustment accuracy under the condition of updating UE specific TA or open loop TA before uplink transmission (applying TA command).
* Option 1b: (QC)
	+ NTN TA adjustment accuracy requirement should be the same as the current TA adjustment requirements with the following modifications:
		- UE autonomous TA adjustment due to updates of UE position estimation, satellite position prediction, and feeder link time drift shall be excluded from the definition of TA adjustment error in response to TAC, i.e. “a relative accuracy to the signalled timing advance value compared to the timing of preceding uplink transmission” shall be modified to not include UE autonomous TA update due to satellite position update and N\_{TA,common} update.
		- To resolve the uncertainty on the amount of additional TA adjustment due to UE position estimation, TA adjustment error margin shall be extended by [10]% of the effective UE position estimation error that is assumed for the derivation of UE initial transmission timing error (50m).
		- The requirement applies only to a stationary UE.
* Recommended WF
	+ The legacy NR TA adjustment accuracy requirements defined in TS 38.133 can be reused for NTN case.
	+ FFS on the additional conditions for NTN TA adjustment accuracy requirement.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| QC | Option 1b.We can’t stop UE from updating both open loop and closed loop TA. In other words, UE may keep updating open loop even when closed loop TA is received. Therefore, a certain margin due to open loop update also needs to be considered. Here, the amount of margin is just to allow a small variation in open loop TA update. |
| Ericsson | The WF is fine. |
| Apple | Option 1. The TA adjustment accuracy requirement is only to verify if UE could adjust the timing based on TA command. |
| Xiaomi | Support the recommended WF. |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic #1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

*Note: The tdoc decisions shall be provided in Section 3 and this table is optional in case moderators would like to provide additional information.*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on … | YYY |  |
| LS on … | ZZZ | To: RAN\_X; Cc: RAN\_Y |
|  |  |  |

**Existing tdocs**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation**  | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics incl. existing and new tdocs.
2. For the Recommendation column please include one of the following:
	1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
	2. Other documents: Agreeable, Revised, Noted
3. For new LS documents, please include information on To/Cc WGs in the comments column
4. Do not include hyper-links in the documents

## 2nd round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation**  | **Comments** |
| R4-210xxxx | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-210xxxx | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-210xxxx | LS on … | ZZZ | Agreeable, Revised, Noted |  |
|  |  |  |  |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics.
2. For the Recommendation column please include one of the following:
	1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
	2. Other documents: Agreeable, Revised, Noted
3. Do not include hyper-links in the documents

# Annex

Contact information

|  |  |  |
| --- | --- | --- |
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Note:

1. Please add your contact information in above table once you make comments on this email thread.
2. If multiple delegates from the same company make comments on single email thread, please add you name as suffix after company name when make comments i.e. Company A (XX, XX)