**3GPP TSG-RAN WG4 Meeting #99-e R4-210XXXX**

**Electronic Meeting, 19th – 27th May, 2021**

**Agenda item:** 9.12.4.3

**Source:** Moderator (Xiaomi)

**Title:** Email discussion summary for [99-e][230] NR\_NTN\_solutions\_RRM\_2

**Document for:** Information

# Introduction

The scope of this email discussion is core timing requirements for NR NTN (AI 9.12.4.3). 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 9.12.4.3 Timing requirements
* UE specific TA estimation accuracy
* UE transmit timing requirements
  + UE initial transmit timing error
  + Gradual timing adjustment
* TA adjustment accuracy requirements
  + TA adjustment accuracy requirement in RRC\_IDLE mode
  + TA adjustment accuracy requirement in RRC\_CONNECTED mode
* Reply LS for the incoming LS R1-2102263

The following schedule is proposed for email discussions in 1st and 2nd rounds:

* 1st round:
  + Moderator kick off email discussion (Wed. 19 May)
  + Companies provide comments for the 1st round (Wed. 19 May – Fri. 9:00 UTC 12 May)
  + Moderator summarize the status and possible proposals, recommending what decisions can be made for 1st round. A formal t-doc will be used (Fri. 19:00 UTC 12 May)
* 2nd round:
  + Companies provide comments for 2nd round starting from Mon. 3:00 UTC 23 May
  + Companies’ comments shall stop by Wed. 19 UTC, 26 May
  + Moderator provide 2nd round summary with a formal tdoc by Thu. 8:00 UTC, 27 May

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: UE timing requirements

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2108971 | Qualcomm Incorporated | **UE specific TA estimation error**  **Proposal 1: RAN4 to investigate whether there is any issue due to a conflict between UE specific TA update periodicity, i.e. open loop TA update, and Network controlled close loop TA update, hence, explicitly resolution and/or spec handling.**  **Proposal 2: RAN4 does not define UE specific TA estimation accuracy requirement.**  **Initial Transmit Timing Error**  **Observation 1: A maximum composite UE initial transmission timing error in NTN consists of maximum of UE position estimation error, maximum of satellite position estimation error, and the current timing error limits.**  **Observation 2: A-GNSS requirements of TS38.171 are not relevant for NR NTN requirement development.**  **Observation 3: Stringent requirements on UE position estimation error will lead to detrimental impacts on overall UE power consumption and a degree of integration of NR transceiver and GNSS receiver.**  **Observation 4: UE power consumption impact due to frequent GNSS measurements and interactions between NR UR transceiver and UE GNSS receiver differs by UE RRC State.**  **Observation 5: Inter-symbol and -carrier orthogonality in uplink can be preserved even with 5Ts relaxation of initial timing error requirement.**  **Observation 6: For handheld type FR1 NTN terminals, a 10Ts relaxation of initial timing error requirement can prolong UE battery life while preserving inter-symbol and -carrier orthogonality in uplink.**  **Proposal 3: NTN UE initial timing error requirements should be relaxed to account for at least 50m of a composite position estimation error.**   * **For FR1 NTN UE in RRC Connected state, the requirement should be further relaxed to accommodate a composite position estimation error up to 100ms.**   **TA Adjustment Accuracy**  **Proposal 4: Request RAN1 whether and how to reflect a propagation delay change, i.e. open loop TA update, from a slot when UE received timing advance command to a slot when the indicated timing advance shall be applied to uplink transmission. If defined, depending on RAN1 design NTN UE timing advance adjustment accuracy requirements may have to be relaxed to account for UE position and satellite position estimation error. And if it is decided to relax the requirement, the accuracy requirement relaxation shall be the same as that for initial timing error requirement**  **Gradual Timing Adjustment**  **Observation 7: The current gradual timing adjustment requirements cannot be applied to NTN systems.**  **Proposal 5: NTN UE gradual timing adjustment requirements should be differently defined from the legacy ones, and the following aspects should be taken into consideration.**   * **Whether or not different requirements need to be defined for different NTN topologies in terms of, e.g. GEO, MEO, LEO, HAPS, HIBS, altitude, elevation angles for feeder/service links, UE speed, etc.** * **Whether and how to account for feeder link propagation delay time change.** * **A framework on UE timing adjustment which will be provided by RAN1.** |
| R4-2109058 | CATT | **Proposal 1: RAN4 should confirm the accuracy of ephemeris data and accuracy of UE PVT from satellit system and GNSS system, and confirm the accuracy of extrapolation from ephemeris data and GNSS based on ephemeris data mode and UE mobility mode.**  **Proposal 2: Don’t define** **a separate accuracy requirement for UE specific TA estimation accuracy. It will be included in the requirement of total UE transmit timing error.**  **Proposal 3: Defer discussion for specifying UE behavior related to UE specific TA estimation, and wait RAN1 conclusion.**  **Proposal 4: It is not necessery to define the update periodicity of UE specific TA value. It depends on UE implementation. UE should meet the requirement defined in RRM specification for UE transmit timing error with a update rate of ephemeris data.**  **Proposal 5: The NTN UE initial transmit timing error should be relaxed, and may be relaxed to [1/10]CP ~ [1/2]CP for different SCS. The relaxed part is allowed for NTN UE specific estimation accuracy.**  **Proposal 6: The gradual timing adjustment requirements should be different for different NTN topologies.**  **Proposal 7: It is not necessery to define TA adjustment accuracy requirement in RRC\_idle mode. The transmit timing in RRC\_idle mode should meet requirements for NTN UE initial transmit timing error.**  **Proposal 8: The Tq and Tp in TN system can be reused. But the maximum aggregate adjustment rate will be defined based on different NTN topologies, such as Tq per [20] ms for LEO600km cell, but Tq per [60]s for GEO.** |
| R4-2109059 | CATT | RAN4 would like to thank RAN1 for the LS on NTN UL time and frequency synchronization requirements. In last RAN4 meeting, a response LS has sent to RAN1 for NTN UL frequency synchronization requirement and concluded the requirement will be ±0.1ppm. RAN4 further investigated time synchronization requirements and would like to give the following response.  The UE initial transmit timing error need to be relaxed compared to NR requirement in 38.133 based on Te in TN specification. The relaxation is determined by NTN UE specific time advance estimation accuracy and the NTN UE specific time advance estimation accuracy is [TBD]. |
| R4-2109220 | Intel Corporation | Proposal 1: RAN4 defines UE specific TA estimation and update accuracy requirements to guarantee fair UE UL transmission timing.  Proposal 2: An NTN UE is required to correctly estimate and update the UE specific TA value in every certain periodicity, based on its GNSS positions and satellite ephemeris information.  Observation 1: it is RAN1 to decide whether the UE updates the specific TA value by substitute TA values or by TA differences.  Proposal 3: 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.  Observation 2: Open and close loop specific timing requirements are pending other WG discussions. |
| R4-2109254 | Xiaomi | **Proposal 1: Not define a separate accuracy requirement for UE specific TA estimation.**  **Proposal 2: The UE specific TA estimation error is consist of the accuracy of A-GNSS position estimation (ΔUE-pos) and the accuracy of serving-satellite ephemeris (ΔSat-pos).**  **Observation 1: The 2-D position error of A-GNSS requirement defined in TS38.171 is not suitable for UE specific TA estimation error estimation.**  **Proposal 3: the UE specific TA estimation accuracy is defined as 10Ts.**  **Proposal 4: Not to specify the update periodicity for UE specific TA estimation.**   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Frequency Range | SCS of SSB signals [kHz] | SCS of uplink signals [kHz] | Te | UE specific TA estimation accuracy | Te\_NTN | | 1 | 15 | 15 | 12\*64\*Tc | 10Ts | 22\*64\*Tc | |  |  | 30 | 10\*64\*Tc | 10Ts | 20\*64\*Tc | |  |  | 60 | 10\*64\*Tc | 10Ts | 18\*64\*Tc | |  | 30 | 15 | 8\*64\*Tc | 10Ts | 18\*64\*Tc | |  |  | 30 | 8\*64\*Tc | 10Ts | 18\*64\*Tc | |  |  | 60 | 7\*64\*Tc | 10Ts | 15\*64\*Tc | | 2 | 120 | 60 | 3.5\*64\*Tc | 10Ts | 10\*64\*Tc | |  |  | 120 | 3.5\*64\*Tc | 10Ts | 10\*64\*Tc | |  | 240 | 60 | 3\*64\*Tc | 10Ts | 8\*64\*Tc | |  |  | 120 | 3\*64\*Tc | 10Ts | 8\*64\*Tc |   **Proposal 5: the Te requirement in NTN is shown in table 1.**  **Observation 2: The gradual timing adjustment step size and adjustment rate need to be revised due to the maximum delay variation in the gradual timing adjustment requirement in NTN.**  **Proposal 6: In LEO scenario, 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 = 25\*Ts.**  **2) The minimum aggregate adjustment rate shall be Tp\_NTN = 100Ts per 100ms.**  **3) The maximum aggregate adjustment rate shall be Tq\_NTN = 25\*Ts per 20 ms.**  **Proposal 7: In GEO scenario, the existing timing adjustment rules defined in TS38.133 can be applied.**  **Observation 3: The TA update accuracy should consider not only the inaccuracy of the received TA command adjustment, but also the inaccuracy of estimated UE autonomous TA adjustment and the network-controlled common TA adjustment.**  **Proposal 8: RAN4 is to define a relaxed TA adjustment accuracy requirement for NR NTN.** |
| R4-2109493 | CMCC | ***Proposal 1: In order to measure the UE specific TA accuracy, take the following assumptions as the starting point:***   * ***For GNSS accuracy, take 50m as the worst case and 20m as the typical case;*** * ***For PVT accuracy, take the precise PVT information as the starting point, and further update after RAN1 achieving the conclusion.***   ***Proposal 2: Do not define a separate*** ***UE specific TA estimation accuracy requirement.***  ***Proposal 3: Define a minimum update periodicity for the UE specific TA estimation.***  ***Proposal 4: The revisited Te requirement for NTN can take the following tables as the baseline. Further update the values in bracket squares after achieving the conclusions about GNSS accuracy and PVT accuracy.***   |  |  |  |  | | --- | --- | --- | --- | | **Frequency Range** | **SCS of SSB signals (kHz)** | **SCS of uplink signals (kHz)** | **Te (worst-case)** | | 1 | 15 | 15 | (12+[5])\*64\*Tc=[17]\*64\*Tc | |  |  | 30 | [15]\*64\*Tc | |  |  | 60 | [15]\*64\*Tc | |  | 30 | 15 | [13]\*64\*Tc | |  |  | 30 | [13]\*64\*Tc | |  |  | 60 | [12]\*64\*Tc | | 2 | 120 | 60 | [8.5]\*64\*Tc | |  |  | 120 | [8.5]\*64\*Tc | |  | 240 | 60 | [8]\*64\*Tc | |  |  | 120 | [8]\*64\*Tc | | Note 1: Tc is the basic timing unit defined in TS 38.211 [6] | | | |  |  |  |  |  | | --- | --- | --- | --- | | **Frequency Range** | **SCS of SSB signals (kHz)** | **SCS of uplink signals (kHz)** | **Te(typical-case)** | | 1 | 15 | 15 | (12+[2])\*64\*Tc=[14]\*64\*Tc | |  |  | 30 | [12]\*64\*Tc | |  |  | 60 | [12]\*64\*Tc | |  | 30 | 15 | [10]\*64\*Tc | |  |  | 30 | [10]\*64\*Tc | |  |  | 60 | [9]\*64\*Tc | | 2 | 120 | 60 | [5.5]\*64\*Tc | |  |  | 120 | [5.5]\*64\*Tc | |  | 240 | 60 | [5]\*64\*Tc | |  |  | 120 | [5]\*64\*Tc | | Note 1: Tc is the basic timing unit defined in TS 38.211 [6] | | | |   ***Proposal 5: In FR1, The maximum aggregate adjustment rate shall be Tq per Xms, Tq value use [255/200\*X]\*64\*Tc as the baseline, a candidate set of X can be [50ms, 40ms, 20ms], the specific value can be further discussed***  ***Proposal 6: Do not define TA adjustment accuracy requirement in RRC\_IDLE mode.***  ***Proposal 7: Revisit the TA adjustment accuracy requirement in RRC\_CONNECTED mode, the specific relaxed value can be decided after RAN1 achieve the agreements about the timing relationship of TA command.*** |
| R4-2109714 | LG Electronics Inc. | * ***Proposal 1***: Do not define separate UE specific TA estimation accuracy requirement * ***Proposal 2***: Add timing error for the worst case GNSS accuracy to current UE transmit timing error requirement * ***Proposal 3***: Relaxed timing advance adjustment accuracy requirement should be considered with position estimation error of UE and satellite. * ***Proposal 4***: UE specific TA should be updated in the slot before applying timing advance adjustment for its uplink transmission |
| R4-2109752 | ZTE Corporation | **Proposal : Reuse the existing Te requirements defined in TS 38.133.** |
| R4-2109855 | MediaTek inc. | ***Observation 1****: If GNSS inaccuracy of 50ms at the UE is considered, the timing error at satellite reception will be >1/2 CP in several cases with UL SCS of 60 kHz and 12 kHz.*  ***Observation 2****: If the GNSS inaccuracy of 30ms at the UE is considered, the timing error at satellite reception can be <1/2 CP.*  ***Proposal 1:*** *On top of the legacy Te, the NTN Te can be defined based on*   * *For UL SCS of 15/30 kHz: Δp <= 50 m* * *For UL SCS of 60/120 kHz: Δp <= 30 m* * *where Δp is the GNSS inaccuracy at the UE*   ***Observation 3****: The timing adjustment of NTN UE pre-compensation and TN gradual timing adjustment are in opposite directions.*  ***Proposal 2:*** *Legacy gradual timing adjustment cannot directly reused. The direction of timing adjustment for NTN UE pre-compensation should be further clarified in the requirement.*  ***Observation 4****: UL timing error contributed by UE pre-compensate satellite delay can be within 3% error budget of ±Te, with the prediction time up to 10 s ahead for pre-compensation.* |
| R4-2109896 | NEC | **Proposal 1: RAN4 to define a separate UE specific TA estimation accuracy requirement.**  **Proposal 2: RAN4 to further wait for RAN1 progress to define the Te requirements and possible relaxations compared to NR initial timing error requirements.**  **Proposal 3: RAN4 to reuse the existing TA adjustment accuracy requirement defined in TS 38.133 with considering of UL timing quantization accuracy.**  **Proposal 4: RAN4 to define TA adjustment accuracy requirement for RRC\_IDLE mode** |
| R4-2110302 | Huawei, HiSilicon | ***Proposal 1: The UE initial transmit timing error*** ***requirements for NTN network can be defined as (Te + Tpos), where Te is same as the existing Te requirements in TS38.133 and Tpos is defined as the timing error derived from GNSS positioning error.***  ***Proposal 2: It is suggested to define general GNSS positioning accuracy requirements which can be referred for deriving other RRM requirements.***  ***Proposal 3: It is suggested to introduce new gradual timing adjustment requirements for NTN network.***  ***Proposal 4: It is suggested that the gradual timing adjustment requirements for NTN are applied when the values of NTA and NTA,common are unchanged.***  ***Proposal 5: RAN4 need to study which of the following assumptions will be used to define gradual timing adjustment requirements for NTN network.***   * ***Assumption 1: UE performs timing adjustment for downlink reception timing drifting and UE specific TA change separately*** * ***Assumption 2: UE performs timing adjustment with*** ***combining downlink reception timing drifting and UE specific TA change as one adjustment***   ***Proposal 6: It is suggested that the TA adjustment requirements for NTN network are applied when the value of NTA or NTA,common is updated by network indication.***  ***Proposal 7: It is suggested that the existing TA adjustment accuracy requirements for TN network can be applied for NTN network.*** |
| R4-2110416 | Ericsson | **Observation 1: The UE initial transmit timing error is needed to make sure we avoid Inter Symbol Interference and loose UL throughput and capacity.**  **Observation 2: The existing requirements make sure we fulfil intended UL throughput and capacity in NR.**  **Observation 3: the Delay Spread (DS) is listed as < 150 ns NTN across scenarios in the release 15 study report**  **Proposal 1: Use existing UE initial transmit timing error, Te also for NTN as UE specific estimation accuracy for initial access (or make Te\_NTN = 2\*Te)**  **Observation 4: The UE Timing Advance adjustment accuracy is needed to make sure we avoid Inter Symbol Interference and loose UL throughput and capacity.**  **Proposal 2: Use existing TA adjustment accuracyalso for NTN.**  **Observation 5: The parameter Tq will have to be modified. For a period of 200 ms we could have a worst case delay variation of 246 \* 64 Tc.**  **Observation: 6: Either the period has to be shortened from 200 ms to something smaller, or we need to increase Tq.** |
| R4-2110417 | Ericsson | **For initial access (i.e. PRACH transmission):** An NTN UE will have an initial access error of 2\*Te, where Te is the exiting error in TS 38.133, section 7.1.2).  **For UL transmissions in RRC Connected State:** RAN4 has concludes that for TA adjustment accuracy in RRC Connected State Timing Advance adjustment accuracy requirement depends on:  1) The mechanism of TA adjustment step size determined by RAN1 and the total uncertainty budget and  2) Requirement for UE Timing Advance adjustment accuracy. An NTN UE will have will comply to existing requirement for UE Timing Advance adjustment accuracy in TS 38.133 7.3.2. |
| R4-2111075 | Apple | ***Proposal 1: use the worst case of GNSS positioning accuracy requirement (i.e., 2-D position error = 100m) in TS38.171 as baseline to define the UE timing requirement in NTN.***  ***Proposal 2: UE specific TA estimation accuracy is 20.5\*64\*Tc + Tephemeris\_uncertainty. Tephemeris\_uncertainty is the satellite position error due to ephemeris information and UE calculation.***  ***Proposal 3: wait RAN1/RAN2 conclusions on*** ***UE specific TA pre-compensation reporting to determine whether we need to define separate UE specific TA estimation requirement or not.***  ***Proposal 4: No need to define UE behavior for UE specific TA estimation (e.g., estimation periodicity) as a requirement, as long as UE can meet the timing requirement, i.e., Te/Tq/Tp.***  ***Proposal 5: The NTN Te requirement with relaxation shall not exceed (half CP – 8\*64\*Tc) for FR1 and half CP for FR2 on UL.***  ***Proposal 6: when ephemeris information is used to derive UE specific TA in Te requirement, the error due to ephemeris uncertainty shall not be considered.***  ***Proposal 7: the Te requirement for NTN is defined by:***   * ***FR1 NTN Te requirement: min{(legacy Te + 20.5\*64\*Tc), (half CP – 8\*64\*Tc)}*** * ***FR2 NTN Te requirement: min{(legacy Te + 20.5\*64\*Tc), half CP }***  |  |  |  |  |  | | --- | --- | --- | --- | --- | | *Frequency Range* | *SCS of SSB signals (kHz)* | *SCS of uplink signals (kHz)* | *Te for NTN* | Note | | ***1*** | ***15*** | ***15*** | ***32.5\*64\*Tc*** | ***min{(legacy Te + 20.5\*64\*Tc), (half CP – 8\*64\*Tc)}***  ***note: 60kHz FR1 Te is not smaller than FR2 60kHz Te*** | |  |  | ***30*** | ***28\*64\*Tc*** | |  |  | ***60*** | ***18\*64\*Tc*** | |  | ***30*** | ***15*** | ***32.5\*64\*Tc*** | |  |  | ***30*** | ***28\*64\*Tc*** | |  |  | ***60*** | ***18\*64\*Tc*** | | ***2*** | ***120*** | ***60*** | ***18\*64\*Tc*** | ***min{(legacy Te + 20.5\*64\*Tc), half CP }*** | |  |  | ***120*** | ***9\*64\*Tc*** | |  | ***240*** | ***60*** | ***18\*64\*Tc*** | |  |  | ***120*** | ***9\*64\*Tc*** |   ***Proposal 8: RAN4 to define new gradual timing adjustment (Tp/Tq) for NTN.***  ***Proposal 9: the design principle for gradual timing adjustment requirement is:***  ***Tp=Tq***  ***Where,***  ***Tdrift is the UE time drifting during 200ms;***  ***Vrelative is the relative speed between UE and satellite***  ***T\_granularity is the UE UL timing granularity***  ***digRF\_margin is the margin for digital RF, i.e., 1.5\*64\*Tc.***  ***Proposal 10: Not define*** ***TA adjustment accuracy requirement for NTN UE in IDLE mode.***  ***Proposal 11:in RRC connected mode, the legacy NR TA adjustment accuracy requirement could be reused for NTN case.*** |
| R4-2111271 | Nokia, Nokia Shanghai Bell | **Observation 1: The UE GNSS-based time pre-compensation has the main purpose to guarantee that the initial random access attempt falls into the time window for the RACH occasion as defined by the gNB and minimize the interference to adjacent UL time symbols. Frequency pre-compensation shall ensure that the Doppler effect is mitigated so that the preamble can be received without inter-carrier/-user interference.**  **Observation 2: There are several sources of inaccuracy in acquiring time and frequency synchronization between UE and gNB by using GNSS information: lag of the ephemeris information, precision of the ephemeris data, GNSS inaccuracy, orbit perturbations and altitude modelling, delay on GNSS acquisition and information conversion at the UE and atmospheric delays.**  **Proposal 1: RAN4 should discuss how a UE can determine it accuracy from GNSS is accurate enough to fulfil the initial transmission timing error requirements.**  **Observation 3: Using *referenceTimeInfo-R16* and GNSS-provided time reference to calculate TA at the UE will suffer less from the satellite movement and timing errors and can serve as a second source for determining whether the initial transmission timing requirements are fulfilled.**  **Proposal 2: RAN4 should discuss whether the use os the time provided by *referenceTimeInfo-R16* is beneficial to securing that the initial transmission timings are kept by a UE.**  **Proposal 3: RAN4 to set requirements on how open loop TA control in RRC connected mode should be applied in a way that does not impact the closed loop TA control messages.** |
| R4-2111477 | THALES | **Proposal 1:** RAN4 should consider the NTN UE transmit timing error requirements to be the same as the ones already specified for TN UEs.  **Proposal 2:** The NTN UE initial transmission timing error requirement should apply when it is the first transmission in a DRX cycle for PUCCH, PUSCH and SRS or it is the PRACH transmission.  **Proposal 3:** The accuracy of UE specific TA estimation () and self-estimated TA common () is counted into the UE transmit timing error requirement.  **Proposal 4:** UE specific TA estimation () and self-estimated TA common () accuracy shall be also defined as a separate accuracy requirement.  **Proposal 5:** Specify UE behavior related to the combination of UE specific TA estimation () and self-estimated TA common ().  **Proposal 6:** The time reference for the UE transmit timing control requirement shall be the downlink timing of the reference cell minus . Therefore, the UE transmit timing error requirement does not cover the self-TA estimation errors.  **Proposal 7:** For PRACH transmission, the NR NTN UE shall be able to self-estimate with an accuracy better than ± ,  depending on the PRACH format and configuration.  **Proposal 8:** In connected mode, the NR NTN UE shall be able to self-estimate with an accuracy better than ±  depending on the numerology in use.  **Proposal 9:** For PRACH transmission, the NR NTN UE shall be able to self-estimate its with an accuracy better than ± ,  depending on the PRACH format and configuration.  **Proposal 10:** In connected mode, the NR NTN UE shall be able to self-estimate its with an accuracy better than ±  depending on the numerology in use.  **Proposal 11:** For PRACH transmission, the NR NTN UE shall be able to self-estimate with an accuracy better than ± ,  depending on the PRACH format and configuration.  **Proposal 12:** In connected mode, the NR NTN UE shall be able to self-estimate with an accuracy better than ±  depending on the numerology in use.  **Observation 1:** One shall distinguish between orbit determination performance based on past measurements of the satellite trajectory and orbit prediction performance that concerns the future satellite trajectory.  **Observation 2:** As a rule of thumb, it can be assumed that there is a factor of 1000 between the position error (in [m]) and the velocity error (in [m/s]). Is important to keep in mind this rule when allocating an error budget for satellite position and velocity estimations.  **Observation 3:** The orbit prediction accuracy depends on:   1. The accuracy of the orbit determination used to derive the satellite ephemeris; 2. The accuracy of the orbit propagation model; 3. The time horizon over which the prediction is made.   **Observation 4:** The PV accuracy target reference hypothesis could use Position error < 30 m and Velocity error < 30 mm/s.  **Observation 5:** Even for a satellite system with “low quality” orbit determination algorithm, challenging operations relying on accurate prediction of satellite trajectories such as Doppler compensation can be performed reliably. |

## 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

In last meeting, RAN4 was agreed to The UE specific TA estimation accuracy is counted into the UE transmit timing error requirement, and FFS the UE specific TA estimation accuracy and whether to define a separate accuracy requirement.

* + - The UE specific TA estimation accuracy is counted into the UE transmit timing error requirement
      * UE specific TA estimation accuracy is FFS
      * FFS whether the UE specific TA estimation accuracy shall be also defined as a separate accuracy requirement
      * Specify UE behavior related to UE specific TA estimation and the detailed behavior is FFS
    - FFS on the update periodicity of UE specific TA value

**Issue 1-1-1: Whether to define a separate accuracy requirement for UE specific TA estimation?**

* Option 1: (Intel, NEC, THALES)
  + Yes
* Option 2: (QC, CATT, Xiaomi, CMCC, LGE, QC, CATT)
  + No
* Recommended WF
  + Companies are encouraged to provide their views on this issue.

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| **Company** | **Comments** |
| Apple | Option 2. This accuracy could be reflected in the other RRM requirement and it’s not testable. |
| Xiaomi | Support option 2. Since this accuracy has been accounted in Te requirements, no need to define a separate requirement. |
| Huawei | Support option 2.  Since the UE specific TA estimation error is counted into UE transmit timing error, there is no need to define the UE specific TA estimation accuracy as a separate accuracy requirement. |
| LGE | Support option 2.  Even if the accuracy requirement for UE specific TA estimation is defined, it is difficult to test the performance accuracy, so it is better to include transmit error requirement. |
| MTK | Option 2 regarding the testability. |
| Qualcomm | Option 2. Same comment as Apple and Xiaomi. |
| CATT | We support option 2. The transmit timing error is tested at UE antenna as a whole. It cannot be separated from different error components. |
| Ericsson | Both options work. The total budget should be agreed upon, then we can decide how to bookkeep. |
| ZTE | Option 2. Same comments as Huawei. |
| THALES | We do not see any issue for testing Option 1 with some reference sources (e.g. for GNSS and ephemeris data, in static or dynamic conditions). |
| NEC | If there is no issue with testability we prefer option 1. |
| CMCC | Option 2.  We understand the reason that companies would like to define a separate accuracy requirement, since Te is only suitable for initial transmission. However, this separate accuracy can not be tested.  From our point of view, we can define a maximum UE specific TA updated period to guarantee the accuracy of UE specific TA. |
| Intel | Ok to that the test cases are not carried out to test the estimation accuracy. But UE behaviour has to be defined in RAN4 spec in accordance with the RAN1 PHY design. For example we need to specify for the NTN UE that the UE is capable of specific estimation when applying combined calculated TA values to UL timing adjustment so that it is guaranteed that the network also adjust accordingly to have the correct reception of the UL signals. |

**Issue 1-1-2: UE specific TA estimation accuracy**

* Option 1: (CATT)
  + RAN4 should confirm the accuracy of ephemeris data and accuracy of UE PVT from satellit system and GNSS system, and confirm the accuracy of extrapolation from ephemeris data and GNSS based on ephemeris data mode and UE mobility mode.
* Option 2: (Xiaomi)
  + The UE specific TA estimation error is consist of the accuracy of A-GNSS position estimation (ΔUE-pos) and the accuracy of serving-satellite ephemeris (ΔSat-pos).
  + The UE specific TA estimation accuracy is defined as 10Ts.
* Option 3: (CMCC)
  + In order to measure the UE specific TA accuracy, take the following assumptions as the starting point:
    - For GNSS accuracy, take 50m as the worst case and 20m as the typical case;
    - For PVT accuracy, take the precise PVT information as the starting point, and further update after RAN1 achieving the conclusion.
* Option 4: (Apple)
  + UE specific TA estimation accuracy is 20.5\*64\*Tc + Tephemeris\_uncertainty. Tephemeris\_uncertainty is the satellite position error due to ephemeris information and UE calculation.
* Option 5: (Ericsson)
  + Use existing UE initial transmit timing error, Te also for NTN as UE specific estimation accuracy for initial access.
* Option 6: (THALES)
  + For PRACH transmission, the NR NTN UE shall be able to self-estimate its with an accuracy better than ± ,  depending on the PRACH format and configuration.
  + Proposal 10: In connected mode, the NR NTN UE shall be able to self-estimate its with an accuracy better than ±  depending on the numerology in use.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

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| **Company** | **Comments** |
| Apple | Option 4. We are using the worst case of the GNSS measurement accuracy (100m) for starting point but we are open to discuss which GNSS measurement accuracy could be used. |
| Xiaomi | Option 2, this issue depends on the assumption of position error for UE GNSS position (issue 1-2-3) and whether the ephemeris error should be accounted (Issue 1-2-1). |
| Huawei | The UE specific TA estimation accuracy mainly relies on GNSS accuracy. The GNSS accuracy can be different for the same UE under different conditions. The satellite allocation and corresponding signal power levels for the assumed GNSS accuracy need to be provided. For example, if the GNSS accuracy used for UE transmit timing requirements is assumed as 50 meters, then the conditions defined in Table 6.17 in TS36.171 can be used for UE transmit timing requirements. |
| MTK | It would be good to discuss 1-2-3 and 1-2-1 first. 10\*Ts would be too-loose, especially for higher UL SCS. |
| Qualcomm | We do not see the point of defining UE specific TA estimation accuracy. If that is because we want to come up with a specific value to understand how much UE Tx timing error needs to be relaxed, it should be at least 5\*64\*Tc (corresponding to 50m service link distance estimation error) and it can be larger depending on UL SCS. And technically UE specific TA estimation error can differ by the following aspects even for the same UE GNSS position estimation error:   1. Serving satellite elevation angle 2. GNSS location information reading frequency 3. Satellite ephemeris information error 4. Satellite ephemeris information reading frequency   Satellite position prediction error |
| CATT | In Issue 1-1-1, we support not to define separate requirement. If just discuss what should be considered in UE specific TA estimation accuracy in this issue, we think it contains the UE positioning error and the error calculated by extrapolation from ephemeris data. |
| Ericsson | To clarify Option 5 “Use existing UE initial transmit timing error, Te also for NTN as UE specific estimation accuracy for initial access”, we mean that in previous RAN4 studies (R4-1912197, one-shot timing adjustments) Ericsson has proposed that we can add one Te (1 x Te) in top of existing UL timing errors (Initial timing error, TA adjustment accurracy and quantization error). This would still define acceptable gNB perfromace in gNB UL RX. In this extra 1 x Te any UE specific TA estimation errors due to satellite position error and UE position error, should fit.  However, in our contribution to this thread, R4-2110416, we have not accounted for the regulation of the feeder link (NTA\_common). This is a problem. If the regulation of the feeder link, based on a RAN1 mechanism, adds, say a further 10% of the CP, then the entire acceptable error budget is wasted. For SCS = 15 kHz we have 10% \* 144 Ts > 12 Ts, where 12 Ts is the proposed extra margin of 1 x Te (for SCS = 15 kHz). In this case a UE specific allowance of 1xTe is too much. |
| THALES | We prefer option 6.  However, if required, another tradeoff can be used between and .  The condition says that the NR NTN UE shall be able to self-estimate with an accuracy better than ± ,  depending on the PRACH format and configuration. From this, if we consider a 50-50 distribution between service link compensation TA UE-Specific) and feederlink (TA common) we get NR NTN UE shall be able to self-estimate its with an accuracy better than ± ,  depending on the PRACH format and configuration.  Same reasoning is applicable for connecting mode, leading to NR NTN UE shall be able to self-estimate with an accuracy better than ±  depending on the numerology in use, and then to NR NTN UE shall be able to self-estimate its with an accuracy better than ±  depending on the numerology in use. |
| NEC | UE specific TA estimation depends on UE position estimate and quantization error of satellite ephemeris. First we need to agree on the UE position accuracy and from there we can arrive at UE specific TA estimation accuracy. |
| CMCC | It seems that the UE specific TA estimation error is consist of the accuracy of A-GNSS position estimation (ΔUE-pos) and the accuracy of serving-satellite ephemeris (ΔSat-pos) is the common understanding among most of companies. Companies have different views about how to capture the accuracy of A-GNSS position estimation (ΔUE-pos) and the accuracy of serving-satellite ephemeris (ΔSat-pos). We support Option2 here and open to discuss other candidate solutions. |

**Issue 1-1-3: Whether to define the update periodicity for UE specific TA estimation?**

* Option 1: (Intel, CMCC)
  + Yes
    - An NTN UE is required to correctly estimate and update the UE specific TA value in every certain periodicity, based on its GNSS positions and satellite ephemeris information. (Intel)
* Option 2: (CATT, Xiaomi, Apple)
  + No
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Option 2. It’s UE implementation and no need to specify as long as UE can meet the timing requirement, i.e., Te/Tq/Tp.. |
| Xiaomi | Support option2, no need to define such requirement as long as UE can meet the timging requirement. |
| Huawei | Support option 2.  There is no need to specify the update periodicity for UE specific TA estimation which is up to UE implementation. The maximum aggregate adjustment rate and the minimum aggregate adjustment rate implicitly requires that the update periodicity be within a certain range. |
| LGE | The update periodicity for UE specific TA estimation should be considered, but in our understanding, this issue is discussing in RAN1. |
| MTK | Prefer to Option 2. |
| Qualcomm | Option 2. |
| CATT | We support option 2. In our discussion paper, we mentioned that the update periodicity of UE specific TA value should depend on UE implementation. No need to define such requirements. UE just needs to meet the timing requirement. |
| Ericsson | Option1. Updating the UE-specific TA value I think cannot be entirely up to the UE, some degree of network control is desirable. |
| ZTE | Option 2. |
| THALES | Option 2  Most probably is a UE implementation issue.  On the other hand, we need to define the periodicity of BS/NTN system transmitting ephemeris data and other parameters such as TA common. |
| CMCC | Option 1.  First, we want to clarify that the Te requirement is only suitable for initial transmission. For subsequent transmissions, whether the error of UE specific TA can be controlled in a reasonable range is unknown. Some companies proposed to define a separate UE specific TA requirement to solve this issue, but in our view, this requirement can not be tested. Therefore, we support to define a maximum update periodicity for UE specific TA estimation to guarantee the UE specific TA accuracy. |
| Intel | There has to be UE behaviour defined either in RAN1 or in RAN4. Ok that we don’t test it. But if RAN1 does not specify the periodicity, RAN4 shall do it to guarantee the minimum performance of the UE. At least to define a upper bound of the value. |

**Issue 1-1-4: UE behaviour related to UE specific TA estimation**

* Option 1: (CATT)
  + Defer discussion for specifying UE behaviour related to UE specific TA estimation, and wait RAN1 conclusion.
* Option 2: (THALES)
  + Specify UE behaviour related to the combination of UE specific TA estimation () and self-estimated TA common ().
* Option 3 (Apple):
  + No need to define UE behavior for UE specific TA estimation as a requirement, as long as UE can meet the timing requirement, i.e., Te/Tq/Tp.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

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| --- | --- |
| **Company** | **Comments** |
| Apple | Option 3. |
| Xiaomi | Option 3 |
| Huawei | Support option 3.  UE performs autonomous timing adjustment according to gradual timing adjustment requirements, which considers downlink timing drifting and UE specific TA updating. |
| Qualcomm | Option 3. |
| CATT | The behavior should be defined in RAN1 side. RAN4 just define the timing requirements. Whether to define in addition, wait for RAN1 to see there is more information. |
| Ericsson | We support Option 2: Specify UE behaviour related to the combination of UE specific TA estimation (N\_(TA,UE-specific)) and self-estimated TA common (N\_(TA,common)). It is important for total system performance, down to receiving gNB in the UE -> Service\_link -> Sat -> feeder\_link -> GW -> gNB. |
| ZTE | Option 3. |
| THALES | Option 2.  As previously explained, such combination may be useful especially for higher SCS. Since the CP is lower, we may need to consider a higher compensation margin for TA common for example, if we assume that the UE self-estimation is very reliable (since we have both GNSS and ephemeris data, and good UE precision in self-estimating next values based on previous ones). We could consider for example 1\*CP/8 (TA UE specific) and 3\*CP/8 (TA common) or other combination for a total of CP/2. |
| CMCC | This issue seems related with Issue 1-1-3 since UE specific TA update is a kind of UE behavior. We propose to postpone the discussion for specifying UE behaviour related to UE specific TA estimation in RAN4, until RAN1 achieve the conclusions about all issues about UE specific TA estimation. |
| Intel | Agree with Huawei exactly.  But this is exactly defining the UE behaviour when applying UL timing adjustment related to UE specific TA estimation. Since the legacy Te requirements apply only for the first transmissions, we need to explicitly change Te to fit the periodic adjustments.  Option 2. |

**Issue 1-1-5: GNSS related accuracy**

* Option 1: (CATT)
  + RAN4 should confirm the accuracy of ephemeris data and accuracy of UE PVT from satellit system and GNSS system, and confirm the accuracy of extrapolation from ephemeris data and GNSS based on ephemeris data mode and UE mobility mode.
* Option 2: (Nokia)
  + RAN4 should discuss how a UE can determine it accuracy from GNSS is accurate enough to fulfil the initial transmission timing error requirements.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

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| **Company** | **Comments** |
| Apple | Existing GNSS related accuracy could be used as side condition to apply NTN timing requirement, but we disagree to modify/control/limit/determine GNSS measurement performance according to NTN timing requirement. |
| Xiaomi | Similar view as Apple, the GNSS related accuracy can be used as the side condition when defining other RRM requirements. |
| Huawei | Same comments as issue 1-1-2.  The corresponding satellite conditions for the assumed GNSS accuracy need to be defined for UE timing requirements. |
| Qualcomm | Share the same view as Apple. It should be just a side condition for NTN UE requirement development. GNSS requirement shouldn’t be directly regulated by other RRM requirements. |
| CATT | In another mail thread of NTN RRM, it is agreed that GNSS accuracy will not defined in 3GPP. We just use the GNSS accuracy to RRM requirements such as timing requirements. To avoid duplicated discussion, should we discuss the issue in one email thread? |
| Ericsson | Option 2: The main error term will come from UE positioning accuracy. |
| Nokia | Option 2. |
| THALES | Option 1.  In our paper R4-2111477 we have provided some information with respect to accuracy of satellite orbit determination and prediction, and ephemeris/PVT data from satellite system.  For GNSS accuracy we can still use some initial assumptions (as also discussed in RAN4#98bis-e). |
| CMCC | We think this issue is a duplicate of the issues in email thread 229. Suggest to defer the discussion here. |

**Issue 1-1-6: UE specific TA estimation requirement for UE specific TA pre-compensation reporting**

* Option 1: (Apple)
  + Wait RAN1/RAN2 conclusions on UE specific TA pre-compensation reporting to determine whether we need to define separate UE specific TA estimation requirement or not.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Option 1. |
| Xiaomi | Fine with option 1. |
| MTK | Fine with option 1. |
| Qualcomm | Okay with Option 1. It’s also up to quantization level in signaling and whether/how a reference slot for UE specific TA estimation is defined even if the reporting introduced. |
| CATT | It makes sense to wait RAN1/RAN2 conclusions. Similar view in Issue 1-1-4. Need further input from RAN1/RAN2. |
| Ericsson | Option 1. |
| ZTE | Option 1. |
| THALES | Option 1.  However, the most important is to have a solution that works.  Moreover, this was a RAN2 decision. We should not forget that we still need to answer to RAN1 with respect to UE specific TA estimation requirement. |
| CMCC | Option 1 is fine. Basically, we think UE specific TA estimation requirement is not needed since it can not be tested in RAN4. However, we are fine with wait for RAN1/2 conclusions, and decide after the input. |

**Issue 1-1-7: whether to define a separate accuracy requirement for self-estimated TA common ()?**

* Option 1: (THALES)
  + Yes.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

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| --- | --- |
| **Company** | **Comments** |
| Apple | No. Based on RAN1 definition, NTA\_common is network-controlled common TA, and may include any timing offset considered necessary by the network, so we don’t see necessity/justification to define requirement for UE self-estimated TA common. |
| Xiaomi | No, as NTA\_common is a network-controlled value. |
| Huawei | Support not to define a separate accuracy requirement for self-estimated TA common.  NTA,common is network controlled. UE calculate the value of NTA,common according to the related signaling. If the total TA value needs to be adjusted due to NTA,common change, the TA adjustment requirements can be applied. |
| LGE | For the clarification, what is the meaning of the self-estimated TA common? TA common is signaled from network. |
| Qualcomm | Same comment as Apple and Xiaomi. |
| CATT | No. NTA\_common is estimated by gNB and sent to UE. No need to define the requirement in RRM spec. |
| Ericsson | Option 1. |
| ZTE | Need some clarification , does this accuracy requirement means the quantization accuracy of the value of NTA common? Or a requirement to limit the value range of NTA common indicated by the network? |
| THALES | Option 1.  TA common is signaled from network, indeed, but is important to know how the UE will pre-compensate based on 2 values TA UE-Specific & TA Common, since NR NTN UE should be able to self-estimate .  The UE self-estimation is also based on received TA common from the NW, and the question is how the UE will use this value. Please take a look at our TDOC R4-2111477 |
| CMCC | Based on our understanding, the is configured by network. Therefore, no need to define a separate accuracy requirement for |

**Issue 1-1-8: If yes for issue 1-7, the accuracy requirement for self-estimated TA common ()?**

* Option 1: (THALES)
  + For PRACH transmission, the NR NTN UE shall be able to self-estimate with an accuracy better than ± ,  depending on the PRACH format and configuration.
  + In connected mode, the NR NTN UE shall be able to self-estimate with an accuracy better than ±  depending on the numerology in use.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

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| **Company** | **Comments** |
| Ericsson | It is very good to discuss accuracy requirement for . We know from other studies (of TN one-shot timing) that we could add 1 x Te onto existing uncertainties. This is 12 Ts at SCS = 15 kHz.  The problem with   is that it clould potentially allocate a very large portion of total error to . |
| THALES | Option 1, for the reasons previously explained.  Please take a look at our TDOC R4-2111477. |
| Intel | Subject to 1-1-7 |

**Issue 1-1-9: whether to define a separate accuracy requirement for the combination of ?**

* Option 1: (THALES)
  + Yes.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

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| --- | --- |
| **Company** | **Comments** |
| Apple | No. similar comments to issue 1-1-1 and issue 1-1-7. |
| Xiaomi | No, as NTA\_common is a network-controlled value. |
| Huawei | UE performs autonomous timing adjustment for UE specific TA (NTA,UE-specific) change and the gradual timing adjustment requirements are applied. UE performs TA adjustment for NTA,common change and the TA adjustment requirements are applied. There is no need to define a separate accuracy requirement for the combination of (NTA,UE-specific + NTA,common). |
| Qualcomm | No. |
| CATT | No need to define such requirement. |
| Ericsson | We support option 1. It is very important to give visibility to the feeder link in the NTN discussion in RAN4, since the total system performance depends on all links in the system achieving at list acceptable minimum performance. |
| THALES | Option 1, for the reasons previously explained.  Please take a look at our TDOC R4-2111477. |

**Issue 1-1-10: If yes for issue 1-9 the accuracy requirement for self-estimated TA common ()?**

* Option 1: (THALES)
  + For PRACH transmission, the NR NTN UE shall be able to self-estimate with an accuracy better than ± ,  depending on the PRACH format and configuration.
  + In connected mode, the NR NTN UE shall be able to self-estimate with an accuracy better than ±  depending on the numerology in use.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

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| **Company** | **Comments** |
| Ericsson | It is very good to discuss accuracy requirement for . We know from other studies (of TN one-shot timing) that we could add 1 x Te onto existing uncertainties. This is 12 Ts at SCS = 15 kHz.  The problem with is that it clould potentially allocate a very large portion of total error to . |
| THALES | Option 1, for the reasons previously explained.  Please take a look at our TDOC R4-2111477. |
| Intel | Subject to 1-1-10 |

**Issue 1-1-11: Whether UE should use the referenceTimeInfo-R16 and GNSS-provided time reference to calculate TA at the UE.**

* Option 1: (Nokia)
  + FFS
    - RAN4 should discuss whether the use os the time provided by referenceTimeInfo-R16 is beneficial to securing that the initial transmission timings are kept by a UE.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Need FFS. referenceTimeInfo-R16 without timeInfoType is same as GNSS timing reference, but if referenceTimeInfo-R16 with timeInfoType=*localClock*, we are not sure if it’s beneficial for this NTN case. For instance, if ground gNB could have GNSS capability, then UE, satellite and ground gNB could sync to the same GNSS reference timing, and we do not see benefit to use *localClock* in this case. |
| Xiaomi | This issue should be discussed and decided by other WGs, |
| Huawei | It depends on RAN1’s discussion. |
| Qualcomm | Out of RAN4 scope. |
| CATT | It’s work at RAN1/RAN2 side. |
| Ericsson | Not RAN4 scope. |
| ZTE | TA calculation should be discussed by RAN1. |
| THALES | RAN1/RAN2 |

### UE transmit timing requirements

In RAN4#98bis-e meeting, the discussion on UE transmit timing requirements was summarized as follows:

* UE initial transmit timing error (Te)
  + Te requirement in NTN is consist of:
    - Same types of errors as terrestrial UE e.g. DL timing estimation accuracy and UL timing setting accuracy. and;
    - UE specific estimation accuracy;
  + FFS on whether and how much different relaxations are required for different sets of SCS of SSB and SCS of uplink signals
  + It is the total NTN UE Te error that decides UL performance, no matter the source of inaccuracy.
* N\_TA\_offset
  + The existing N\_TA offset value defined in Table 7.1.2-2 in TS38.133 can be reused in NTN
* Gradual timing adjustment
  + FFS whether to define new gradual timing adjustment requirements for NTN UE
    - FFS whether and how to count the maximum delay variation for the round trip delay;
    - FFS: whether define different requirements for different NTN topologies in terms of, e.g. GEO, MEO, LEO, HAPS, HIBS, altitude, elevation angles for feeder/service links, UE speed, etc;
    - FFS the reference timing for the Gradual timing adjustment in NTN
    - One shot timing adjustment
      * Not introduce one shot timing adjustment requirement for NTN UE

**Issue 1-2-1: The composites should be considered for initial transmit timing requirement in NTN (Te\_NTN).**

* Option 1: (QC, Xiaomi)
  + UE position estimation error
  + Serving-satellite position estimation error
  + The current UE transmit timing error requirement
* Option 1a: (LGE, MTK, Huawei)
  + GNSS inaccuracy
  + The current UE transmit timing error requirement
* Option 2: (Apple)
  + legacy Te
  + UE specific TA estimation error (without ephemeris uncertainty)
* Option 3: (THALES)
  + The accuracy of UE specific TA estimation (N\_(TA,UE-specific)) and self-estimated TA common (N\_(TA,common)) is counted into the UE transmit timing error requirement.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

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| --- | --- |
| **Company** | **Comments** |
| Apple | Option 2. Ephemeris uncertainty is up to network implementation, like error of common TA or error of TA command from network, we do not think it’s necessary to include this ephemeris uncertainty in UE Te requirement. |
| Xiaomi | Option 1, as the satellite position is calculated at UE side, thus the related accuracy should be accounted in Te requirement. |
| Huawei | Support option 1a.  Serving-satellite position estimation error is related to the signalling design and independent of UE capability. We suggested to define the Te requirements based on UE capability.  If companies consider that Serving-satellite position estimation error need to be included, option 1 is also acceptable for us. |
| LGE | We support option 1 and option 1a. Add timing error for the worst case GNSS accuracy to current UE transmit timing error requirement |
| MTK | Support 1a, and open to discuss Serving-satellite position estimation error.  Te requirement should not include Serving-satellite position estimation error, but this error can be considered as assumption when defining the Te requirement. |
| Qualcomm | Option 1. Serving satellite position estimation error due to ephemeris information reading frequency and satellite position prediction can be a part of composite TA estimation error depending on test framework design. |
| CATT | Do not agree option 3. The transmit timing error shouldn’t consist of NTA\_common.  The same part in option 1 and 1a and 2 is the current Te, which we agree.  “UE position estimation error” or “GNSS inaccuracy” we think they are the same, if not, please clarify further. They are included in “UE specific TA estimation error”. We agree the wording “UE specific TA estimation error” but need Apple’s further clarification of the word in bracket.  In our understanding, it should be “current Te”+”UE specific TA estimation error”. The “UE specific TA error” contains the UE positioning error and the error calculated by extrapolation from ephemeris data. |
| Ericsson | Option 3. |
| ZTE | Option 1 and option 1a. |
| THALES | Option 3, for the reasons previously explained |
| NEC | Our understanding is option 1 |
| CMCC | Option 1. |

**Issue 1-2-2: Whether A-GNSS requirements of TS38.171 can be referred for Te\_NTN requirement.**

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

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| --- | --- |
| **Company** | **Comments** |
| Apple | Option 1. We think 38.171 is the only standardized GNSS performance requirement that we can use, since GNSS implementation is diverse among different UEs. We are fine to choose a requirement in TS38.171 under certain scenario(e.g., not the worst case) as a side condition for NTN timing requirement design. |
| Xiaomi | If we follow the minimum performance requirement defined in TS38.171, e.g. position error = 100m, then the Te requirement for NTN will be exceeded half CP in larger SCS cases. But we are fine to choose an appropriate requirement defined in TS38.171 under certain scenario other than the worst case as the side condition for timing requirements. |
| Huawei | Support option 1.  The positioning accuracy requirements and corresponding conditions defined in section 6.5 can be referred for NTN Te requirements. |
| Qualcomm | As a baseline, we are okay with Option 1. But what is more important is which specific requirement in 38.171 should be taken as a reference. |
| CATT | We support option 1. 38.171 can be used as reference unless there is more reasonable source. |
| Ericsson | Option 2. A-GNSS requirements are too loose. We get required position accuracy need from 114 meters to 26 meters. However this analysis in R4-2110418 allocated no uncertainty to the feeder link. This means that we get even stricter requirements than our analysis in R4-2110418. |
| ZTE | Option 1. |
| THALES | Option 1, but it can also be improved. |
| CMCC | Option 1 as the baseline. A-GNSS requirements of TS38.171 can be a baseline, but it can not be used for Te\_NTN requirement directly, since 100m GNSS accuracy can not guarantee UL timing all the time. |

**Issue 1-2-3: GNSS position error assumption for Te\_NTN requirement.**

* Option 1: (QC)
  + at least 50m, and further relax up to 100m
* Option 2: (Xiaomi)
  + 50m
* Option 3: (CMCC)
  + 50m as the worst case and 20m as the typical case
* Option 4: (MTK)
  + For UL SCS of 15/30 kHz: <= 50 m
  + For UL SCS of 60/120 kHz: <= 30 m
* Option 5: (Apple, LGE)
  + The worst case: 100m
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

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| --- | --- |
| **Company** | **Comments** |
| Apple | Option 5. But we can also compromise to use 50m GNSS accuracy as the side condition for NTN timing requirement design. |
| Xiaomi | Option 2, and option 4 is also acceptable for us. |
| Huawei | The GNSS accuracy can be different for the same UE under different conditions. The satellite allocation and corresponding signal power levels for the assumed GNSS accuracy need to be provided. |
| LGE | We support option 5. It is related reference GNSS scenario, and it is better to consider worst case scenario for requirements. |
| MTK | Option 4.  We need to make sure the timing error received at satellite is controlled with a reasonable range, e.g. half CP in larger SCS cases. |
| Qualcomm | Option 1. It is a bit unclear if companies assume GNSS position error will be directly converted into service link distance estimation error, i.e. 2D position vs. 3D distance. |
| CATT | Option 2 or option 3. |
| Ericsson | We need to agree total error budget nefore we split into terms. We get 114-26 m if we ignore the feeder link uncertainty. If that is included we get stricter requirements than 114 to 26 meters. |
| Nokia | Location error including UE GNSS and satellite ephemeris/PVT inaccuracies, up to 100m should be supported. |
| THALES | Option 2 or Option 4. |
| NEC | We prefer option 4 |
| CMCC | Option 3. It seems most companies are OK with 50m, maybe 50m can be a starting point. |
| Intel | We support Option 4. |

**Issue 1-2-4: Whether to define general GNSS positioning accuracy requirements?**

* Option 1: (Huawei)
  + Yes, it is suggested to define general GNSS positioning accuracy requirements which can be referred for deriving other RRM requirements.
* Option 2: ()
  + FFS
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Cannot agree on option 1. We don’t need to define GNSS measurement in this WI, but we are fine to use one of the GNSS measurement performance in TS38.171 as a side condition for NTN timing requirement design. |
| Xiaomi | Agree with Apple’s views. |
| Huawei | The assumed GNSS accuracy is discussed for UE transmit timing requirements. RAN4 can further study whether to use the same GNSS accuracy for deriving other RRM requirements. We are open for this issue. If different GNSS accuracy is assumed for deriving other RRM requirements, then the corresponding satellite conditions need to be investigated. |
| Qualcomm | GNSS position accuracy requirements shouldn’t be directly regulated by NTN RRM requirement. |
| CATT | It’s out of scope to define the GNSS positioning accuracy requirements. Is it the UE capability to use different GNSS performance? It means multiple sets of requirements. |
| Ericsson | Yes, define general GNSS positioning accuracy requirements once we agree on acceptable total error. |
| Nokia | Option 1. |
| THALES | Option 1. We can also use instead of defining. |
| CMCC | Option2. The GNSS positioning accuracy is out of RAN4’s scope, it can be defined implicitly in every RRM requirements. |
| Intel | Maybe not explicit requirements but a basic assumption is needed. |

**Issue 1-2-5: Initial transmit timing error (Te\_NTN)**

* Option 1: (QC)
  + NTN UE initial timing error requirements should be relaxed to account for at least 50m of a composite position estimation error.
    - For FR1 NTN UE in RRC Connected state, the requirement should be further relaxed to accommodate a composite position estimation error up to 100ms.
* **Table 3: T’e Timing Error Limit when a total UE positioning error is allowed up to 50m**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Frequency Range | SCS of SSB signals [kHz] | SCS of uplink signals [kHz] | Te | Te [us] | max(Tch) [us] | max(Tch)/Tcp [%] | Max(T’e) |
| 1 | 15 | 15 | 12\*64\*Tc | 0.39 | 3.57 | 76 | 17\*64\*Tc |
|  |  | 30 | 10\*64\*Tc | 0.33 | 1.35 | 58 | 15\*64\*Tc |
|  |  | 60 | 10\*64\*Tc | 0.33 | 0.17 | 15 | 15\*64\*Tc |
|  | 30 | 15 | 8\*64\*Tc | 0.26 | 3.83 | 82 | 13\*64\*Tc |
|  |  | 30 | 8\*64\*Tc | 0.26 | 1.49 | 64 | 13\*64\*Tc |
|  |  | 60 | 7\*64\*Tc | 0.23 | 0.38 | 32 | 12\*64\*Tc |
| 2 | 120 | 60 | 3.5\*64\*Tc | 0.11 | 0.62 | 53 | 8.5\*64\*Tc |
|  |  | 120 | 3.5\*64\*Tc | 0.11 | 0.03 | 6 | 8.5\*64\*Tc |
|  | 240 | 60 | 3\*64\*Tc | 0.098 | 0.64 | 55 | 8\*64\*Tc |
|  |  | 120 | 3\*64\*Tc | 0.098 | 0.06 | 10 | 8\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 | | | | | | |  |

**Table 4: T’e Timing Error Limit when a total UE positioning error is allowed up to 100m**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Frequency Range | SCS of SSB signals [kHz] | SCS of uplink signals [kHz] | Te | Te [us] | max(Tch) [us] | max(Tch)/Tcp [%] | Max(T’e) |
| 1 | 15 | 15 | 12\*64\*Tc | 0.39 | 3.24 | 72 | 22\*64\*Tc |
|  |  | 30 | 10\*64\*Tc | 0.33 | 1.02 | 66 | 20\*64\*Tc |
|  | 30 | 15 | 8\*64\*Tc | 0.26 | 3.5 | 75 | 18\*64\*Tc |
|  |  | 30 | 8\*64\*Tc | 0.26 | 1.16 | 49 | 18\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 | | | | | | |  |

* Option 2: (CATT)
  + The NTN UE initial transmit timing error should be relaxed, and may be relaxed to [1/10]CP ~ [1/2]CP for different SCS. The relaxed part is allowed for NTN UE specific estimation accuracy.
* Option 3: (Xiaomi)
  + The Te requirement in NTN is shown in table 1.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Frequency Range | SCS of SSB signals [kHz] | SCS of uplink signals [kHz] | Te | UE specific TA estimation accuracy | Te\_NTN |
| 1 | 15 | 15 | 12\*64\*Tc | 10Ts | 22\*64\*Tc |
|  |  | 30 | 10\*64\*Tc | 10Ts | 20\*64\*Tc |
|  |  | 60 | 10\*64\*Tc | 10Ts | 18\*64\*Tc |
|  | 30 | 15 | 8\*64\*Tc | 10Ts | 18\*64\*Tc |
|  |  | 30 | 8\*64\*Tc | 10Ts | 18\*64\*Tc |
|  |  | 60 | 7\*64\*Tc | 10Ts | 15\*64\*Tc |
| 2 | 120 | 60 | 3.5\*64\*Tc | 10Ts | 10\*64\*Tc |
|  |  | 120 | 3.5\*64\*Tc | 10Ts | 10\*64\*Tc |
|  | 240 | 60 | 3\*64\*Tc | 10Ts | 8\*64\*Tc |
|  |  | 120 | 3\*64\*Tc | 10Ts | 8\*64\*Tc |

**Table 1: Te requirement in NTN**

* Option 4: (CMCC)
  + The revisited Te requirement for NTN can take the following tables as the baseline. Further update the values in bracket squares after achieving the conclusions about GNSS accuracy and PVT accuracy.

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency Range** | **SCS of SSB signals (kHz)** | **SCS of uplink signals (kHz)** | **Te (worst-case)** |
| 1 | 15 | 15 | (12+[5])\*64\*Tc=[17]\*64\*Tc |
|  |  | 30 | [15]\*64\*Tc |
|  |  | 60 | [15]\*64\*Tc |
|  | 30 | 15 | [13]\*64\*Tc |
|  |  | 30 | [13]\*64\*Tc |
|  |  | 60 | [12]\*64\*Tc |
| 2 | 120 | 60 | [8.5]\*64\*Tc |
|  |  | 120 | [8.5]\*64\*Tc |
|  | 240 | 60 | [8]\*64\*Tc |
|  |  | 120 | [8]\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 [6] | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **Frequency Range** | **SCS of SSB signals (kHz)** | **SCS of uplink signals (kHz)** | **Te(typical-case)** |
| 1 | 15 | 15 | (12+[2])\*64\*Tc=[14]\*64\*Tc |
|  |  | 30 | [12]\*64\*Tc |
|  |  | 60 | [12]\*64\*Tc |
|  | 30 | 15 | [10]\*64\*Tc |
|  |  | 30 | [10]\*64\*Tc |
|  |  | 60 | [9]\*64\*Tc |
| 2 | 120 | 60 | [5.5]\*64\*Tc |
|  |  | 120 | [5.5]\*64\*Tc |
|  | 240 | 60 | [5]\*64\*Tc |
|  |  | 120 | [5]\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 [6] | | | |

* Option 5: (ZTE, THALES)
  + Reuse the existing Te requirements defined in TS 38.133.
* Option 6: (NEC)
  + RAN4 to further wait for RAN1 progress to define the Te requirements and possible relaxations compared to NR initial timing error requirements.
* Option 7: (Huawei)
  + The UE initial transmit timing error requirements for NTN network can be defined as (Te + Tpos), where Te is same as the existing Te requirements in TS38.133 and Tpos is defined as the timing error derived from GNSS positioning error.
* Option 8: (Ericsson)
  + Te\_NTN = 2\*Te
* Option 9: (Apple)
  + The NTN Te requirement with relaxation shall not exceed (half CP – 8\*64\*Tc) for FR1 and half CP for FR2 on UL.
  + When ephemeris information is used to derive UE specific TA in Te requirement, the error due to ephemeris uncertainty shall not be considered.
  + The Te requirement for NTN is defined by:
    - FR1 NTN Te requirement: min{(legacy Te + 20.5\*64\*Tc), (half CP – 8\*64\*Tc)}
    - FR2 NTN Te requirement: min{(legacy Te + 20.5\*64\*Tc), half CP }

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Frequency Range* | *SCS of SSB signals (kHz)* | *SCS of uplink signals (kHz)* | *Te for NTN* | Note |
| *1* | *15* | *15* | *32.5\*64\*Tc* | *min{(legacy Te + 20.5\*64\*Tc), (half CP – 8\*64\*Tc)}*  *note: 60kHz FR1 Te is not smaller than FR2 60kHz Te* |
|  |  | *30* | *28\*64\*Tc* |
|  |  | *60* | *18\*64\*Tc* |
|  | *30* | *15* | *32.5\*64\*Tc* |
|  |  | *30* | *28\*64\*Tc* |
|  |  | *60* | *18\*64\*Tc* |
| *2* | *120* | *60* | *18\*64\*Tc* | *min{(legacy Te + 20.5\*64\*Tc), half CP }* |
|  |  | *120* | *9\*64\*Tc* |
|  | *240* | *60* | *18\*64\*Tc* |
|  |  | *120* | *9\*64\*Tc* |

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

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| --- | --- |
| **Company** | **Comments** |
| Apple | Option 9. Up to conclusions from other issues. |
| Xiaomi | Option 3, it depends on the outcome of issue 1-2-1 and 1-2-3. |
| Huawei | The Te\_NTN requirements depend on the conclusion on the other issues. |
| MTK | Fine with Option 8/9. And Option 7 is generally fine to us.  And the idea is to control the aggregated timing error received at satellite, i.e., (legacy Te + TAC resolution error + TA adj. accuracy + GNSS inaccuracy) < 1/2 CP of UL SCS, as analyzed in our paper R4-2109855.  On Option 1/Option 4 (worst case), 5\*Ts with “50m” assumption is ok for UL SCS of 15kHz/30kHz. But for higher SCS it will not ensure aggregated timing error < 1/2 CP.  On Option 3, 10\*Ts is higher than “50m” assumption. |
| Qualcomm | Can revisit after other issues pertaining to UE position error/UE specific TA estimation error are settled. |
| CATT | Option 2. For the final exact values, it needs the conclusion of other open issues. Therefore, we just propose the general rule here. When other open issues are finalized, the table can be decided. |
| Ericsson | Our own option 8, might be too relaxed..  In previous RAN4 studies (R4-1912197, one-shot timing adjustments) Ericsson has proposed that we can add one Te (1 x Te) in top of existing UL timing errors (Initial timing error, TA adjustment accurracy and quantization error). This would still define acceptable gNB performance in gNB UL RX. In this extra 1 x Te any UE specific TA estimation errors due to satellite position error and UE position error, should fit.  However, in our contribution to this thread, R4-2110416, we have not accounted for the regulation of the feeder link (NTA\_common). This is a problem. If the regulation of the feeder link, based on a RAN1 mechanism, adds, say a further 10% of the CP, then the entire acceptable error budget is wasted. For SCS = 15 kHz we have 10% \* 144 Ts > 12 Ts, where 12 Ts is the proposed extra margin of 1 x Te (for SCS = 15 kHz). In this case a UE specific allowance of 1xTe is too much. |
| ZTE | Option 5 is preferred. |
| THALES | After the correction using CP/2 self-estimation condition (as R4-2111477), Option 5 should apply. |
| NEC | Signalling details of satellite ephemeris is not finalized in RAN1. Quantization error of satellite ephemeris will have impact on final error value. Hence we prefer Option 6 and wait for RAN1 to finalize the signaling details. |
| CMCC | Option4. This issue is related with Issue 1-2-3. Besides, we would like to keep this issue open and further check whether the existing Te can be added to updated Te directly or some updated to the existing Te before adding is needed. |

**Issue 1-2-6: Whether define different gradual timing adjustment requirements for different NTN topologies** **e.g. GEO, MEO, LEO.**

* Option 1: (CATT, Xiaomi)
  + Yes
* Option 2: (QC, CMCC)
  + FFS
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Option 2. Since the frequency/time drifting and relative speed between UE and satellite is unclear so far, we may need to wait for more conclusions from RF and RAN1. However, we propose to discuss the methodology of designing Tp/Tq requirement first. |
| Xiaomi | Option 1, according to the TR38.821, for GEO scenario, the maximum delay variation can be negligible. |
| Huawei | Option 2 |
| MTK | Option 2 |
| Qualcomm | Option 2. We prefer to first try to reach a consensus on UE specific TA estimation issue and Te. But open to discussion on the methodology of designing Tp/Tq requirements. |
| CATT | We support option 1. The GEO is static while other types are not. The level of time adjustment is different. |
| Ericsson | Option1, is reasonable. It is not a strong position. |
| ZTE | Option 2. |
| THALES | Option 2 is fine. We also agree GEO is static. |
| NEC | We are OK with option 2. |
| CMCC | Option 2. We are also open to Option1. If Option1 is agreed, then the applicability rule for test cases may be needed. |
| Intel | Option 2. |

**Issue 1-2-7: Which assumptions will be used to define gradual timing adjustment requirements for NTN network?**

* Option 1: (Huawei)
  + Assumption 1: UE performs timing adjustment for downlink reception timing drifting and UE specific TA change separately.
  + Assumption 2: 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** |
| Apple | Assumption 2. Tp and Tq is used to adjust the UE Tx timing to the range of (DL timing +/- Te), and therefore UE would use same Tp/Tq for timing adjustment regardless of which factor (DL drifting or UE specific TA change) causing timing change. |
| Xiaomi | Need some clarification on “UE specific TA change”, does it means the UE specific TA estimation error or the update of the UE specific TA value? |
| Huawei | To Xiaomi  “UE specific TA change” means the update of the UE specific TA value. |
| MTK | Slightly prefer to Assumption 1. Because timing adjustment for legacy downlink reception timing drifting and UE specific TA change are in different direction. |
| Qualcomm | Assumption 2. Same understanding as Apple. |
| CATT | Need conclusion from RAN1 of how to use NTA, NTA, UE-specific, NTA\_Common, i.e. the conclusion of timing adjustment mechanism. In current TN system, gradual timing adjustment is under the same NTA, timing adjustment related to downlink timing. But in NTN system, the mechanism might be different. |
| Ericsson | No strong position. Closer to assumption 1. |
| THALES | Assumption 2 (can be combined). |
| NEC | May be a clarification question. Does it need to be specified? Can’t it be UE implementation? |
| CMCC | Assumption 2 in Option 1. |
| Intel | Assumption 2 is feasible. |

**Issue 1-2-8: Whether the maximum delay variation should be considered in the gradual timing adjustment requirement in NTN?**

* Option 1: (Xiaomi, CMCC, Ericsson)
  + Yes
* Option 2: ()
  + FFS.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Option 1. |
| Xiaomi | Support option1. |
| Huawei | The maximum delay variation of the serving link between the serving satellite and the UE need to be considered in NTN gradual timing adjustment requirement. |
| MTK | Prefer to Option 2, because it would depend on RAN1’s outcome on how much information is provided by network. But open to discuss it. |
| Qualcomm | Option 1. For clarification, the maximum delay variation may need to be differently applied for different type of satellites. |
| CATT | FFS. |
| Ericsson | Option 1. Yes, this is a factor to consider. |
| THALES | Option 2 |
| NEC | May be a clarification question. What is the impact or UE behaviour when we consider this? |

**Issue 1-2-9: Whether to define new gradual timing adjustment requirements for NTN network?**

* Option 1: (QC, Xiaomi, CMCC, Huawei, Ericsson, Apple)
  + Yes
* Option 2: ()
  + FFS.
* Recommended WF
  + RAN4 to introduce new gradual timing adjustment requirements for NTN network.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Option 1. |
| Xiaomi | Option 1 |
| Huawei | Agree with the recommended WF. |
| MTK | Fine with the recommended WF. |
| Qualcomm | Option 1. |
| CATT | Option 1. |
| Ericsson | Option 1: Yes. |
| Nokia | Option 1 |
| THALES | Fine with recommended WF. |
| NEC | OK with recommended WF |

**Issue 1-2-10: Gradual timing adjustment requirement**

* Option 1: (CATT)
  + The Tq and Tp in TN system can be reused. But the maximum aggregate adjustment rate will be defined based on different NTN topologies, such as Tq per [20] ms for LEO600km cell, but Tq per [60]s for GEO.
* Option 2: (Xiaomi)
  + The maximum amount of the magnitude of the timing change in one adjustment shall be Tq\_NTN = 25\*Ts.
  + The minimum aggregate adjustment rate shall be Tp\_NTN = 100Ts per 100ms.
  + The maximum aggregate adjustment rate shall be Tq\_NTN = 25\*Ts per 20 ms.The Tq and Tp can be reused. The maximum aggregate adjustment rate should be Tq per 20ms.
* Option 3: (CMCC)
  + In FR1, The maximum aggregate adjustment rate shall be Tq per Xms, Tq value use [255/200\*X]\*64\*Tc as the baseline, a candidate set of X can be [50ms, 40ms, 20ms], the specific value can be further discussed
* Option 4: (Ericsson)
  + The parameter Tq will have to be modified. For a period of 200 ms we could have a worst case delay variation of 246 \* 64 Tc.
  + Either the period has to be shortened from 200 ms to something smaller, or we need to increase Tq.
* Option 5: (Apple)
  + the design principle for gradual timing adjustment requirement is:
    - Tp=Tq
    - Where,
      * Tdrift is the UE time drifting during 200ms;
      * Vrelative is the relative speed between UE and satellite
      * T\_granularity is the UE UL timing granularity
      * digRF\_margin is the margin for digital RF, i.e., 1.5\*64\*Tc.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Option 5. Up to the conclusions from other issues. |
| Xiaomi | Pending on the conclusions on other issues. |
| Huawei | It depends on the conclusion on issues 1-2-6, 1-2-7 and 1-2-8.  When the propagation delay between serving satellite and UE is changed, both downlink timing and UE specific TA will also be changed accordingly. However, the UE timing adjustment direction due to UE specific TA change is different with the direction due to downlink timing drift. The timing adjustment step combining both downlink timing drift and UE specific TA change need to be considered for gradual timing adjustment requirements. |
| Qualcomm | FFS |
| CATT | The final exact value depends on the conclusion of other issues. Our proposal option 1 is a general proposal. The final value can be discussed. |
| Ericsson | Option 4: What we can say at this stage is either to shorten period or increase parameter value. |
| THALES | FFS |
| NEC | Can be FFS for now |
| CMCC | Based on our understanding, the logic between Option1,2,3,4 is similar, the specific value can be further studied. |

**Issue 1-2-11: In GEO scenarios, whether the existing gradual timing adjustment requirement can be applied**

* Option 1: (Xiaomi, CMCC)
  + Yes
* Option 2: ()
  + FFS
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Option 2 because the UE frequency/timing drifting rate is not clear in RF session yet. |
| Xiaomi | Option 1, according to the TR38.821, for GEO scenario, the maximum delay variation can be negligible. |
| Huawei | Support option 2.  The existing gradual timing adjustment requirements do not capture the timing adjustment due to the update of UE specific TA. |
| Qualcomm | FFS. There are still relevant on-going discussions in RAN1. |
| CATT | Option 2. It may be not applicable. |
| Ericsson | Option 2. |
| ZTE | FFS. Need more discussion, |
| THALES | FFS |
| NEC | NO |

**Issue 1-2-12: The direction of timing adjustment for NTN UE pre-compensation.**

* Option 1: (MTK)
  + The timing adjustment of NTN UE pre-compensation and TN gradual timing adjustment are in opposite directions
  + Legacy gradual timing adjustment cannot directly reused. The direction of timing adjustment for NTN UE pre-compensation should be further clarified in the requirement.
* Option 2: (Intel)
  + 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.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Need more discussion. But we slightly prefer to reuse the same direction assumption as legacy case and let network to send TA command if needed. |
| Xiaomi | Need more discussion. |
| Huawei | Need more discussion.  The propagation delay variation of the serving link between the serving satellite and the UE will cause downlink receive timing drift and UE specific TA change. The direction of timing adjustment due to downlink receive timing drift is same as the direction of propagation delay variation. However, the direction of timing adjustment due to UE specific TA change is opposite to the direction of propagation delay variation. |
| Qualcomm | We found MTK’s observation interesting. Needs more discussion because we’re not sure if that is always the case irrespective of a source of DL timing variation. |
| CATT | FFS. |
| THALES | Agree with Qualcomm. |
| NEC | Can be FFS |
| CMCC | Open to this and need further study. |
| Intel | OK to discuss further. Thanks MTK for proposing an insightful idea but we observe that it is not an existing UE implementation. New UE behaviour has to be defined if it is considered. |

**Issue 1-2-13: The reference timing for UE transmit timing.**

* Option 1: (THALES)
  + The time reference for the UE transmit timing control requirement shall be the downlink timing of the reference cell minus . Therefore, the UE transmit timing error requirement does not cover the self-TA estimation errors.
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Follow the RAN1 definition:  So, reference timing for the UE initial transmit timing control requirement is (DL timing - TTA) |
| Xiaomi | Agree with Apple’s comment. |
| Qualcomm | Is Option 1 different from what Apple mentions? |
| CATT | Agree with Apple. Clarification of “DL timing” is at UE antenna. |
| Ericsson | Option 1. |
| THALES | Option 1 |
| NEC | Option 1 is fine. What is difference between Option 1 and Apple suggested eq.? |
| CMCC | FFS. Option1 points out that the UE transmit timing error requirement does not cover the self-TA estimation errors. However, we have already agreed with the UE transmit timing error requirement cover the self-TA estimation errors. How to define the time reference point to capture this error is a new issue we need to consider. |

### TA adjustment accuracy requirements

In RAN4#98bis-e meeting, the discussion on UE transmit timing requirements was summarized as follows:

* In RRC\_idle mode
  + FFS whether to define TA adjustment accuracy requirement;
  + In RRC\_CONNECTED mode
    - Option 1: Reuse the existing TA adjustment accuracy requirement defined in TS 38.133 with considering of UL timing quantization accuracy.
    - Option 2: FFS on whether relax the TA adjustment accuracy requirement.
      * FFS on UE position and satellite position estimation error;
      * FFS on propagation delay change from a slot when UE received timing advance command to a slot when the indicated TA.

**Issue 1-3-1: Whether to define TA adjustment accuracy requirement in RRC\_IDLE mode**

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

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Option 2 |
| Xiaomi | Option 2 |
| Huawei | Support option 2.  Only UE initial transmit timing requirements need to be applied for PRACH transmission in RRC\_IDLE mode. |
| LG | Support option 2 |
| MTK | Option 2 |
| Qualcomm | Option 2 |
| CATT | Option 2. |
| ZTE | Option 2. |
| THALES | Option 2 |
| NEC | May be we understood this issue wrongly. We are OK with option 2. |

**Issue 1-3-2: Whether the UE position and satellite position estimation error should be accounted for TA adjustment accuracy requirement?**

* Option 1: (Xiaomi, LGE)
  + Yes
* Option 2: (QC, CMCC)
  + Depends on RAN1 design
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | No. TA adjustment error is up to the UE UL timing granularity only. |
| Xiaomi | Option 1, according to RAN1 agreement, for TA update in RRC\_CONNECTED state, combination of both open (i.e. UE autonomous TA estimation, and common TA estimation) and closed (i.e., received TA commands) control loops shall be supported for NTN. Thus, the UE specific TA estimation error should be accounted when UE adjusts its TA. |
| Huawei | No. The UE specific TA estimation error include UE position and satellite position estimation errors. Since RAN4 agreed that UE specific TA estimation error is counted into UE initial transmit timing error, it is not recommended that the UE-specific TA estimation error be counted as the TA adjustment accuracy. |
| LGE | We support option 1, but we are open for option 2. |
| Qualcomm | FFS. It is also up to whether and how to estimate/pre-compensate a propagation delay change and/or UE/satellite position update from a slot when UE received timing advance command to a slot when the indicated timing advance shall be applied to uplink transmission. |
| CATT | We support option 2. |
| Ericsson | The existing legacy analysis how to scale TA adjustment accuracy is fine and existing TA adjustment accuracy can be reused. |
| ZTE | Option 2. |
| Nokia | Option 1 |
| THALES |  |
| NEC | NO. we think it only depends on step size. |
| CMCC | Our consideration is the error introduced by the delay between the UE estimation and UL transmission. Whether to capture this error is depended on UE estimation period (exist or not) and RAN1’s design. We can come back to this issue later. |

**Issue 1-3-3: TA adjustment accuracy requirement in RRC\_CONNECTED mode**

* Option 1: (NEC, Huawei, Ericsson, Apple)
  + Reuse the existing timing advance adjustment accuracy requirements defined in TS 38.133.
* Option 1a: (NEC)
  + RAN4 to reuse the existing TA adjustment accuracy requirement defined in TS 38.133 with considering of UL timing quantization accuracy.
* Option 2: (Xiaomi, CMCC, LGE)
  + RAN4 is to define a relaxed TA adjustment accuracy requirement for NR NTN
* Option 2a: (QC)
  + Request RAN1 whether and how to reflect a propagation delay change, i.e. open loop TA update, from a slot when UE received timing advance command to a slot when the indicated timing advance shall be applied to uplink transmission. If defined, depending on RAN1 design NTN UE timing advance adjustment accuracy requirements may have to be relaxed to account for UE position and satellite position estimation error. And if it is decided to relax the requirement, the accuracy requirement relaxation shall be the same as that for initial timing error requirement.
* Recommended WF
  + Companies are encouraged to provide the views on TA adjustment accuracy requirement in RRC\_CONNECTED mode.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | Option 1. |
| Xiaomi | Option 2, similar comments as issue 1-3-2. |
| Huawei | Support option 1/1a.  The propagation delay change will be captured in the gradual timing adjustment requirement. So, the TA adjustment accuracy depends on uplink timing quantization accuracy, and the existing timing advance adjustment accuracy requirements for TN can be reused for NTN. |
| LGE | Support option 2.  Position accuracy for UE and satellite from GNSS and PVT affects UE transmit timing, and it is also affects timing advance adjustment accuracy since UE specific TA is calculated by position information. Therefore, relaxed timing advance adjustment accuracy requirement should be considered with position estimation error of UE and satellite. And we can discuss this with Issue 1-3-2. |
| MTK | Can we agree on Option 1 for closed control loop and Option 2 for open control loop? |
| Qualcomm | Option 2a. |
| Ericsson | Option 1. |
| THALES |  |
| NEC | Support option 1/1a |
| CMCC | Same consideration with issue 1-3-2. Our consideration is the error introduced by the delay between the UE estimation and UL transmission. Whether to capture this error is depended on UE estimation period (exist or not) and RAN1’s design. We can come back to this issue later. |

**Issue 1-3-4: UE behaviour before applying timing advance adjustment for its uplink transmission.**

* Option 1: (LGE)
  + UE specific TA should be updated in the slot before applying timing advance adjustment for its uplink transmission
* Option 2: ()
  + FFS
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

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| --- | --- |
| **Company** | **Comments** |
| Apple | Cannot agree with option 1. UE specific TA updating is up to UE implementation (when to perform GNSS positioning) and network implementation (when to broadcast the ephemeris info). |
| Xiaomi | FFS |
| Huawei | UE behaviors on how to perform UE specific TA estimation and how to perform the corresponding uplink timing adjustment are up to UE implementation, as long as satisfying Te/Tp/Tq requirements. |
| LGE | To reduce impact of longer propagation delay from TA command at network to adjustment timing for uplink transmission at UE, UE behavior as option 1 should be considered. |
| MTK | It is up to UE implementation as long as the requirements are fulfilled. |
| Qualcomm | FFS. There can be a conflict between network signalled TA and UE autonomously estimated TA. |
| ZTE | It is out of scope of RAN4. |
| THALES | UE implementation issue. |
| CMCC | We think this issue should be discussed in RAN1. |
| Intel | Not tested. Open to have discussions. |

**Issue 1-3-5: Open and closed loop for TA adjustment.**

* Option 1: (Intel)
  + Open and close loop specific timing requirements are pending other WG discussions.
* Option 2: (QC, Nokia)
  + RAN4 to set requirements on how open loop TA control in RRC connected mode should be applied in a way that does not impact the closed loop TA control messages. (Nokia)
  + RAN4 to investigate whether there is any issue due to a conflict between UE specific TA update periodicity, i.e. open loop TA update, and Network controlled close loop TA update, hence, explicitly resolution and/or spec handling. (QC)
* Recommended WF
  + Companies are encouraged to provide the views on this issue.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Intel | Option 1. |
| Xiaomi | FFS, need further input from other WGs. |
| Qualcomm | Option 2. Maybe need an input from other WGs. |
| CATT | Wait for the further conclusion from RAN1. |
| Ericsson | Option 2. |
| ZTE | Option 1. |
| Nokia | Option 2. |
| THALES | Option 2 if possible. |
| NEC | Option 1 |

### Reply LS for the incoming LS (R1-2102263)

RAN1 sent the LS (R1-2102263) to ask RAN4 to provide feedback on NTN UL time and frequency sychronization requirements.

Question 1: What are the NTN UL time synchronization requirements?

* For initial access (i.e. PRACH transmission)
* For UL transmissions in RRC Connected State

Question 2: What are the NTN UL frequency synchronization requirements?

* For initial access (i.e. PRACH transmission)
* For UL transmissions in RRC Connected State

According to the chairman’s guidance, Q1, Q2 will be treated separately in RRM session and RF session and then combined into a single LS reply in the end.

**Issue 1-4-1: What are the NTN UL time synchronization requirements?**

* Option 1: (CATT)
  + RAN4 would like to thank RAN1 for the LS on NTN UL time and frequency synchronization requirements. In last RAN4 meeting, a response LS has sent to RAN1 for NTN UL frequency synchronization requirement and concluded the requirement will be ±0.1ppm. RAN4 further investigated time synchronization requirements and would like to give the following response.
  + The UE initial transmit timing error need to be relaxed compared to NR requirement in 38.133 based on Te in TN specification. The relaxation is determined by NTN UE specific time advance estimation accuracy and the NTN UE specific time advance estimation accuracy is [TBD].
* Option 2: (Xiaomi)
  + The UL time synchronization requirements for NTN will be specified in RAN4 are summarized as follows:
    - Initial access
      * Initial transmit timing error requirement (Te), which is specified in TS38.133 Table 7.1.2-1.
      * TA adjustment accuracy requirement due to UE specific TA estimation.
  + The UL time synchronization requirements for NTN will be specified in RAN4 are summarized as follows:
    - Initial access
      * Initial transmit timing error requirement (Te), which is specified in the following table 1.

Table 1: Te requirement for NR NTN

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| --- | --- | --- | --- | --- | --- |
| Frequency Range | SCS of SSB signals [kHz] | SCS of uplink signals [kHz] | Te | UE specific TA estimation accuracy | Te\_NTN |
| 1 | 15 | 15 | 12\*64\*Tc | 10Ts | 22\*64\*Tc |
|  |  | 30 | 10\*64\*Tc | 10Ts | 20\*64\*Tc |
|  |  | 60 | 10\*64\*Tc | 10Ts | 18\*64\*Tc |
|  | 30 | 15 | 8\*64\*Tc | 10Ts | 18\*64\*Tc |
|  |  | 30 | 8\*64\*Tc | 10Ts | 18\*64\*Tc |
|  |  | 60 | 7\*64\*Tc | 10Ts | 15\*64\*Tc |
| 2 | 120 | 60 | 3.5\*64\*Tc | 10Ts | 10\*64\*Tc |
|  |  | 120 | 3.5\*64\*Tc | 10Ts | 10\*64\*Tc |
|  | 240 | 60 | 3\*64\*Tc | 10Ts | 8\*64\*Tc |
|  |  | 120 | 3\*64\*Tc | 10Ts | 8\*64\*Tc |

* + - UL transmissions in RRC\_CONNECTED state
      * Initial transmit timing error requirement (Te), which is specified in above table 1.
      * Gradual timing adjustment for LEO scenario
        + The maximum amount of the magnitude of the timing change in one adjustment shall be Tq\_NTN = 25\*Ts.
        + The minimum aggregate adjustment rate shall be Tp\_NTN = 100Ts per 100ms.
        + The maximum aggregate adjustment rate shall be Tq\_NTN = 25\*Ts per 20 ms.
      * Gradual timing adjustment for GEO scenario
        + The maximum amount of the magnitude of the timing change in one adjustment shall be Tq.
        + The minimum aggregate adjustment rate shall be Tp per second.
        + The maximum aggregate adjustment rate shall be Tq per 200 ms.
        + Where the maximum autonomous time adjustment step Tq and the aggregate adjustment rate Tp are specified in TS38.133 Table 7.1.2.1-1.
      * TA adjustment accuracy requirement, which is consist of the following parts:
        + Received TA command adjustment accuracy
        + Estimated UE specific TA adjustment accuracy
        + Received Common TA adjustment accuracy
* Option 3: (Ericsson)
  + For initial access (i.e. PRACH transmission): An NTN UE will have an initial access error of 2\*Te, where Te is the exiting error in TS 38.133, section 7.1.2).
  + For UL transmissions in RRC Connected State: RAN4 has concludes that for TA adjustment accuracy in RRC Connected State Timing Advance adjustment accuracy requirement depends on:
    - The mechanism of TA adjustment step size determined by RAN1 and the total uncertainty budget and
    - Requirement for UE Timing Advance adjustment accuracy. An NTN UE will have will comply to existing requirement for UE Timing Advance adjustment accuracy in TS 38.133 7.3.2.
    - Finally, RAN has decided to define UE specific TA estimation accuracy requirement, but no details are available at this point.
* Recommended WF
  + Pending on the conclusion on sub-topic 1.2.1, 1.2.2 and 1.2.3.
  + We should evaluate whether there are enough conclusions to reply this LS after the 1st round discussion. If yes, we can discuss the reply LS during the second round discussion.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Apple | FFS. The answer shall be based on the conclusions from previous issues. |
| Xiaomi | As captured in the recommended WF, we should evaluate whether there are enough conclusions to reply this LS after the 1st round discussion. If yes, we can discuss the reply LS during the second round discussion. |
| Huawei | FFS, the reply depends on the conclusions of other issues. |
| CATT | Agree with the recommended WF now. In our opinion, we can send Reply LS to RAN1 no need to wait all final timing requirements but just some solid conclusion we can achieve in this meeting. |
| Ericsson | Our option 3: (Ericsson) might be too loose and can be considered withdrawn.  In previous RAN4 studies (R4-1912197, one-shot timing adjustments) Ericsson has proposed that we can add one Te (1 x Te) in top of existing UL timing errors (Initial timing error, TA adjustment accurracy and quantization error). This would still define acceptable gNB perfromace in gNB UL RX. In this extra 1 x Te any UE specific TA estimation errors due to satellite position error and UE position error, should fit.  However, in our contribution to this thread, R4-2110416, we have not accounted for the regulation of the feeder link (NTA\_common). This is a problem. If the regulation of the feeder link, based on a RAN1 mechanism, adds, say a further 10% of the CP, then the entire acceptable error budget is wasted. For SCS = 15 kHz we have 10% \* 144 Ts > 12 Ts, where 12 Ts is the proposed extra margin of 1 x Te (for SCS = 15 kHz). In this case a UE specific allowance of 1xTe is too much. |
| ZTE | Wait the conclusion of other issues. |
| THALES | There is no information for the UE self-estimation |

## 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:* |

#### UE specific TA estimation error

**Issue 1-1-1: Whether to define a separate accuracy requirement for UE specific TA estimation?**

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|  | **Status summary** |
| **Issue 1-1-1** | * Option 1: (Intel, NEC, THALES, Ericsson)   + Yes * Option 2: (QC, CATT, Xiaomi, CMCC, LGE, CATT, Apple, Huawei, MTK, Ericsson, ZTE)   + No   After 1st round discussion, 11 companies support to not define a separate accuracy requirement, 4 companies support to define a separate accuracy requirement.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. * The proponents are encouraged to bring the arguments on the necessity and how to test it. |

**Issue 1-1-2: UE specific TA estimation accuracy**

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|  | **Status summary** |
| **Issue 1-1-2** | * Option 1: (CATT)   + RAN4 should confirm the accuracy of ephemeris data and accuracy of UE PVT from satellite system and GNSS system, and confirm the accuracy of extrapolation from ephemeris data and GNSS based on ephemeris data mode and UE mobility mode. * Option 2: (Xiaomi, CMCC)   + The UE specific TA estimation error is consist of the accuracy of A-GNSS position estimation (ΔUE-pos) and the accuracy of serving-satellite ephemeris (ΔSat-pos).   + The UE specific TA estimation accuracy is defined as 10Ts. * Option 3: (CMCC)   + In order to measure the UE specific TA accuracy, take the following assumptions as the starting point:     - For GNSS accuracy, take 50m as the worst case and 20m as the typical case;     - For PVT accuracy, take the precise PVT information as the starting point, and further update after RAN1 achieving the conclusion. * Option 4: (Apple)   + UE specific TA estimation accuracy is 20.5\*64\*Tc + Tephemeris\_uncertainty. Tephemeris\_uncertainty is the satellite position error due to ephemeris information and UE calculation. * Option 5: (Ericsson)   + Use existing UE initial transmit timing error, Te also for NTN as UE specific estimation accuracy for initial access. * Option 6: (THALES)   + For PRACH transmission, the NR NTN UE shall be able to self-estimate its with an accuracy better than ± ,  depending on the PRACH format and configuration.   + Proposal 10: In connected mode, the NR NTN UE shall be able to self-estimate its with an accuracy better than ±  depending on the numerology in use.   After 1st round discussion, companies’ view are quite diverse. And this issue also depends on the assumption of position error for UE GNSS position (issue 1-2-3) and whether the ephemeris error should be accounted (Issue 1-2-1).  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-1-3: Whether to define the update periodicity for UE specific TA estimation?**

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|  | **Status summary** |
| **Issue 1-1-3** | * Option 1: (Intel, CMCC, Ericsson)   + Yes * Option 2: (CATT, Xiaomi, Apple, Huawei, MTK, Qualcomm, ZTE, THALES)   + No * Option : (LGE)   + Under discussion in RAN1   After 1st round discussion, 8 companies support to not define the update rate for UE specific TA estimation, 4 companies support to define a separate accuracy requirement, and 1 company mentioned this issue is discussing in RAN1.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. * Companies are encouraged to double check whether this issue is discussing in RAN1. |

**Issue 1-1-4: UE behaviour related to UE specific TA estimation**

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|  | **Status summary** |
| **Issue 1-1-4** | * Option 1: (CATT, CMCC)   + Defer discussion for specifying UE behaviour related to UE specific TA estimation, and wait RAN1 conclusion. * Option 2: (THALES, Ericsson, Intel)   + Specify UE behaviour related to the combination of UE specific TA estimation () and self-estimated TA common (). * Option 3 (Apple, Xiaomi, Huawei, Qualcomm, ZTE):   + No need to define UE behavior for UE specific TA estimation as a requirement, as long as UE can meet the timing requirement, i.e., Te/Tq/Tp.   After 1st round discussion, 5 companies support to not define UE behavior for UE specific TA estimation as a requirement, 3 companies support to define UE behaviour related to the combination of UE specific TA estimation and self-estimated TA common, and 2 company suggest defer this discussion until RAN1’s further conclusion.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-1-5: GNSS related accuracy**

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|  | **Status summary** |
| **Issue 1-1-5** | * Option 1: (CATT, THALES)   + RAN4 should confirm the accuracy of ephemeris data and accuracy of UE PVT from satellite system and GNSS system, and confirm the accuracy of extrapolation from ephemeris data and GNSS based on ephemeris data mode and UE mobility mode. * Option 2: (Nokia, Ericsson)   + RAN4 should discuss how a UE can determine it accuracy from GNSS is accurate enough to fulfil the initial transmission timing error requirements.   After 1st round discussion, companies’ views are quite diverse. 3 companies suggest use the GNSS related accuracy as the side condition for timing requirements, 2 companies support option 1 and 2 companies support option2.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-1-6: UE specific TA estimation requirement for UE specific TA pre-compensation reporting**

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|  | **Status summary** |
| **Issue 1-1-6** | * Option 1: (Apple)   + Wait RAN1/RAN2 conclusions on UE specific TA pre-compensation reporting to determine whether we need to define separate UE specific TA estimation requirement or not.   After 1st round discussion, all the companies are fine with option 1.  Tentative agreement:  Wait RAN1/RAN2 conclusions on UE specific TA pre-compensation reporting to determine whether we need to define separate UE specific TA estimation requirement or not.  *Recommendations for 2nd round:*   * Companies are double check whether option 1 is agreeable or not. |

**Issue 1-1-7: whether to define a separate accuracy requirement for self-estimated TA common ()?**

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|  | **Status summary** |
| **Issue 1-1-7** | * Option 1: (THALES, Ericsson)   + Yes. * Option 1: (Apple, Xiaomi, Huawei, Qualcomm, CATT, CMCC)   + No.   After 1st round discussion, 6 companies support option 2, 2 companies support option 1 and 2 companies need more clarification.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-1-8: If yes for issue 1-7, the accuracy requirement for self-estimated TA common ()?**

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|  | **Status summary** |
| **Issue 1-1-8** | * Option 1: (THALES)   + For PRACH transmission, the NR NTN UE shall be able to self-estimate with an accuracy better than ± ,  depending on the PRACH format and configuration.   + In connected mode, the NR NTN UE shall be able to self-estimate with an accuracy better than ±  depending on the numerology in use.   After 1st round discussion, only 2 companies provided the comments, this issue depends on the conclusion of issue 1-1-7.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-1-9: whether to define a separate accuracy requirement for the combination of ?**

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| --- | --- |
|  | **Status summary** |
| **Issue 1-1-9** | * Option 1: (THALES, Ericsson)   + Yes. * Option 1: (Apple, Xiaomi, Huawei, Qualcomm, CATT)   + No.   After 1st round discussion, 5 companies support option 2 and 2 companies support option 1.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-1-10: If yes for issue 1-9 the accuracy requirement for self-estimated TA common ()?**

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|  | **Status summary** |
| **Issue 1-1-10** | * Option 1: (THALES)   + For PRACH transmission, the NR NTN UE shall be able to self-estimate with an accuracy better than ± ,  depending on the PRACH format and configuration.   + In connected mode, the NR NTN UE shall be able to self-estimate with an accuracy better than ±  depending on the numerology in use.   After 1st round discussion, only 2 companies provided the comments, this issue depends on the conclusion of issue 1-1-9.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-1-11: Whether UE should use the referenceTimeInfo-R16 and GNSS-provided time reference to calculate TA at the UE.**

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| --- | --- |
|  | **Status summary** |
| **Issue 1-1-11** | * Option 1: (Nokia, Apple)   + FFS     - RAN4 should discuss whether the use os the time provided by referenceTimeInfo-R16 is beneficial to securing that the initial transmission timings are kept by a UE. * Option 1: (Xiaomi, Huawei, Qualcomm, CATT, Ericsson, ZTE THALES)   + Up to RAB1/RAN2 decision   After 1st round discussion, 7 companies suggest this issue is out of RAN4 scope and up to RAN1/RAN2 decision, and 2 companies suggest FFS.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

#### UE transmit timing requirements

**Issue 1-2-1: The composites should be considered for initial transmit timing requirement in NTN (Te\_NTN).**

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|  | **Status summary** |
| **Issue 1-2-1** | * Option 1: (QC, Xiaomi, Huawei, LGE, ZTE, NEC, CMCC)   + UE position estimation error   + Serving-satellite position estimation error   + The current UE transmit timing error requirement * Option 1a: (LGE, MTK, Huawei, ZTE)   + GNSS inaccuracy   + The current UE transmit timing error requirement * Option 2: (Apple)   + legacy Te   + UE specific TA estimation error (without ephemeris uncertainty) * Option 3: (THALES, Ericsson)   + The accuracy of UE specific TA estimation (N\_(TA,UE-specific)) and self-estimated TA common (N\_(TA,common)) is counted into the UE transmit timing error requirement.   After 1st round discussion, 7 companies support option 1. 4 companies support option 1a, 1 companies support option 2 and 2 companies support option 3.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. * Companies are encouraged to provide views on whether the satellite ephemeris error should be accounted in Te requirement. |

**Issue 1-2-2: Whether A-GNSS requirements of TS38.171 can be referred for Te\_NTN requirement.**

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| --- | --- |
|  | **Status summary** |
| **Issue 1-2-2** | * Option 1: (Apple, Huawei, QC, CATT, ZTE, THALES, CMCC)   + Yes * Option 2: (QC, Xiaomi, Ericsson)   + No   After 1st round discussion, 7 companies support option 1 and 3 companies support option 2.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. * Companies are encouraged to provide views on which requirement in TS38.171 can be used as a reference. |

**Issue 1-2-3: GNSS position error assumption for Te\_NTN requirement.**

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| --- | --- |
|  | **Status summary** |
| **Issue 1-2-3** | * Option 1: (QC)   + at least 50m, and further relax up to 100m * Option 2: (Xiaomi, CATT, THALES)   + 50m * Option 3: (CMCC, CATT)   + 50m as the worst case and 20m as the typical case * Option 4: (MTK, Xiaomi, THALES, NEC, Intel)   + For UL SCS of 15/30 kHz: <= 50 m   + For UL SCS of 60/120 kHz: <= 30 m * Option 5: (Apple, LGE, Nokia)   + The worst case: 100m   After 1st round discussion, 1 companies support option 1, 3 companies support option 2, 2companies support option 3, 5 companies support option 4 and 3 companies support option 5.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. * Companies are encouraged to provide views on whether 50m of GNSS position error can be assumed as a starting point. |

**Issue 1-2-4: Whether to define general GNSS positioning accuracy requirements?**

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| --- | --- |
|  | **Status summary** |
| **Issue 1-2-4** | * Option 1: (Huawei, Ericsson, Nokia, THALES)   + Yes, it is suggested to define general GNSS positioning accuracy requirements which can be referred for deriving other RRM requirements. * Option 2: ()   + FFS   After 1st round discussion, 5 companies (Apple, Xiaomi, Qualcomm, CATT, CMCC, Intel ) donot agree option 1 and 4 companies support option 1.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-2-5: Initial transmit timing error (Te\_NTN)**

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| --- | --- |
|  | **Status summary** |
| **Issue 1-2-5** | After 1st round discussion, companies’ views are quite diverse and this issue depends on the outcome of other issues.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-2-6: Whether define different gradual timing adjustment requirements for different NTN topologies** **e.g. GEO, MEO, LEO.**

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| --- | --- |
|  | **Status summary** |
| **Issue 1-2-6** | * Option 1: (CATT, Xiaomi, Ericsson)   + Yes * Option 2: (QC, CMCC, Apple, Huawei, ZTE, THALES, NEC, CMCC, Intel)   + FFS   After 1st round discussion, 9 companies support option 2 and 3 companies support option 1.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-2-7: Which assumptions will be used to define gradual timing adjustment requirements for NTN network?**

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| --- | --- |
|  | **Status summary** |
| **Issue 1-2-7** | * Option 1: (Huawei)   + Assumption 1: UE performs timing adjustment for downlink reception timing drifting and UE specific TA change separately. (Huawei, MTK, Ericsson)   + Assumption 2: UE performs timing adjustment with combining downlink reception timing drifting and UE specific TA change as one adjustment. (Huawei, Apple, QC, THALES, CMCC, Intel)   After 1st round discussion, 3 companies support Assumption 1, 6 companies support Assumption 2, and 3 companies need more clarification.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-2-8: Whether the maximum delay variation should be considered in the gradual timing adjustment requirement in NTN?**

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|  | **Status summary** |
| **Issue 1-2-8** | * Option 1: (Xiaomi, CMCC, Ericsson, Apple, Huawei, QC, Ericsson)   + Yes * Option 2: (CATT, MTK, THALES, NEC)   + FFS.   After 1st round discussion, 7 companies support option 1and 4 companies support option 2.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-2-9: Whether to define new gradual timing adjustment requirements for NTN network?**

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|  | **Status summary** |
| **Issue 1-2-9** | * Option 1: (QC, Xiaomi, Huawei, Ericsson, Apple, MTK, CATT, Nokia, THALES, NEC)   + Yes * Option 2: ()   + FFS   After 1st round discussion, all the companies support option 1.  Tentative agreement:  RAN4 to introduce new gradual timing adjustment requirements for NTN network.  *Recommendations for 2nd round:*   * Companies are encouraged to double check the tentative agreement. |

**Issue 1-2-10: Gradual timing adjustment requirement**

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|  | **Status summary** |
| **Issue 1-2-10** | * Option 1: (CATT)   + The Tq and Tp in TN system can be reused. But the maximum aggregate adjustment rate will be defined based on different NTN topologies, such as Tq per [20] ms for LEO600km cell, but Tq per [60]s for GEO. * Option 2: (Xiaomi)   + The maximum amount of the magnitude of the timing change in one adjustment shall be Tq\_NTN = 25\*Ts.   + The minimum aggregate adjustment rate shall be Tp\_NTN = 100Ts per 100ms.   + The maximum aggregate adjustment rate shall be Tq\_NTN = 25\*Ts per 20 ms.The Tq and Tp can be reused. The maximum aggregate adjustment rate should be Tq per 20ms. * Option 3: (CMCC)   + In FR1, The maximum aggregate adjustment rate shall be Tq per Xms, Tq value use [255/200\*X]\*64\*Tc as the baseline, a candidate set of X can be [50ms, 40ms, 20ms], the specific value can be further discussed * Option 4: (Ericsson)   + The parameter Tq will have to be modified. For a period of 200 ms we could have a worst case delay variation of 246 \* 64 Tc.   + Either the period has to be shortened from 200 ms to something smaller, or we need to increase Tq. * Option 5: (Apple)   + the design principle for gradual timing adjustment requirement is:     - Tp=Tq     - Where,       * Tdrift is the UE time drifting during 200ms;       * Vrelative is the relative speed between UE and satellite       * T\_granularity is the UE UL timing granularity       * digRF\_margin is the margin for digital RF, i.e., 1.5\*64\*Tc.   After 1st round discussion, most companies suggest to further study, and this issue depend on the conclusion of issues 1-2-6, 1-2-7 and 1-2-8.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-2-11: In GEO scenarios, whether the existing gradual timing adjustment requirement can be applied**

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|  | **Status summary** |
| **Issue 1-2-11** | * Option 1: (Xiaomi, CMCC)   + Yes * Option 2: (Apple, QC, CATT, Ericsson, ZTE, THALES)   + FFS * Option 3: (NEC)   + No   After 1st round discussion, 6 companies support option 2, 2 companies support option 1 and 1 company support option 3.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-2-12: The direction of timing adjustment for NTN UE pre-compensation.**

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|  | **Status summary** |
| **Issue 1-2-12** | * Option 1: (MTK)   + The timing adjustment of NTN UE pre-compensation and TN gradual timing adjustment are in opposite directions   + Legacy gradual timing adjustment cannot directly reused. The direction of timing adjustment for NTN UE pre-compensation should be further clarified in the requirement. * Option 2: (Intel)   + 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.   After 1st round discussion, most companies suggest to further study.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-2-13: The reference timing for UE transmit timing.**

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|  | **Status summary** |
| **Issue 1-2-13** | * Option 1: (THALES, Ericsson, NEC)   + The time reference for the UE transmit timing control requirement shall be the downlink timing of the reference cell minus . Therefore, the UE transmit timing error requirement does not cover the self-TA estimation errors.   After 1st round discussion, 3 companies support option 1 and 3 companies (Apple, Xiaomi, CATT) suggest to follow RAN1 definition.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

#### TA adjustment accuracy requirements

**Issue 1-3-1: Whether to define TA adjustment accuracy requirement in RRC\_IDLE mode**

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| --- | --- |
|  | **Status summary** |
| **Issue 1-3-1** | * Option 1: (NEC)   + Yes * Option 2: (CATT, CMCC, Apple, Huawei, Xiaomi, LGE, MTK, QC, ZTE, THALES, NEC)   + No   After 1st round discussion, all the companies support option 2  Tentative agreement:  Not define TA adjustment accuracy requirement in RRC\_IDLE mode.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-3-2: Whether the UE position and satellite position estimation error should be accounted for TA adjustment accuracy requirement?**

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|  | **Status summary** |
| **Issue 1-3-2** | * Option 1: (Xiaomi, LGE, Nokia)   + Yes * Option 2: (QC, CMCC, LGE, CATT, CMCC)   + Depends on RAN1 design * Option 2: (Apple, Huawei, NEC)   + No   After 1st round discussion, 3 companies support option 1, 5 companies support option 2 and 3 companies support option 3.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-3-3: TA adjustment accuracy requirement in RRC\_CONNECTED mode**

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|  | **Status summary** |
| **Issue 1-3-3** | * Option 1: (NEC, Huawei, Ericsson, Apple, MTK, NEC)   + Reuse the existing timing advance adjustment accuracy requirements defined in TS 38.133. * Option 1a: (NEC)   + RAN4 to reuse the existing TA adjustment accuracy requirement defined in TS 38.133 with considering of UL timing quantization accuracy. * Option 2: (Xiaomi, CMCC, LGE)   + RAN4 is to define a relaxed TA adjustment accuracy requirement for NR NTN * Option 2a: (QC)   + Request RAN1 whether and how to reflect a propagation delay change, i.e. open loop TA update, from a slot when UE received timing advance command to a slot when the indicated timing advance shall be applied to uplink transmission. If defined, depending on RAN1 design NTN UE timing advance adjustment accuracy requirements may have to be relaxed to account for UE position and satellite position estimation error. And if it is decided to relax the requirement, the accuracy requirement relaxation shall be the same as that for initial timing error requirement.   After 1st round discussion, 6 companies support option 1, 1 company support option 1a, 3 companies support option 2 and 1 company support option 2a.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-3-4: UE behaviour before applying timing advance adjustment for its uplink transmission.**

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| --- | --- |
|  | **Status summary** |
| **Issue 1-3-4** | * Option 1: (LGE)   + UE specific TA should be updated in the slot before applying timing advance adjustment for its uplink transmission * Option 2: (Xiaomi, QC, Intel)   + FFS * Option 3: (Apple, Huawei, MTK, THALES)   + Up to UE implementation   After 1st round discussion, 1 company support option 1, 3 company support option 2 and 4 companies support option 3.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

**Issue 1-3-5: Open and closed loop for TA adjustment.**

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|  | **Status summary** |
| **Issue 1-3-5** | * Option 1: (Intel, Apple, ZTE, NEC)   + Open and close loop specific timing requirements are pending other WG discussions. * Option 2: (QC, Nokia, Ericsson, THALES)   + RAN4 to set requirements on how open loop TA control in RRC connected mode should be applied in a way that does not impact the closed loop TA control messages. (Nokia)   + RAN4 to investigate whether there is any issue due to a conflict between UE specific TA update periodicity, i.e. open loop TA update, and Network controlled close loop TA update, hence, explicitly resolution and/or spec handling. (QC)   After 1st round discussion, 4 companies support option 1, 4 company support option 2 and 2 companies (Xiaomi, CATT) support FFS.  *Recommendations for 2nd round:*   * Continue the discussion in the 2nd round. |

#### Reply LS for the incoming LS (R1-2102263)

**Issue 1-3-5: Open and closed loop for TA adjustment.**

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|  | **Status summary** |
| **Issue 1-3-5** | After 1st round discussion, most companies suggest to wait for the conclusions of other issues. As moderator, we think there is no enough conclusion to reply this LS after 1st round discussion. It is aimed to reply this LS in next meeting.  *Recommendations for 2nd round:*   * Focus on the discussion on subtopic 1.2.1, 1.2.2 and 1.2.3. * It is aimed to reply this LS in RAN4#100e meeting. |

### 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)

#### UE specific TA estimation error

**Issue 1-1-1: Whether to define a separate accuracy requirement for UE specific TA estimation?**

* Option 1: (Intel, NEC, THALES, Ericsson)
  + Yes
* Option 2: (QC, CATT, Xiaomi, CMCC, LGE, CATT, Apple, Huawei, MTK, Ericsson, ZTE)
  + No

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.
* The proponents are encouraged to bring the arguments on the necessity and how to test it.

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**Issue 1-1-2: UE specific TA estimation accuracy**

* Option 1: (CATT)
  + RAN4 should confirm the accuracy of ephemeris data and accuracy of UE PVT from satellite system and GNSS system, and confirm the accuracy of extrapolation from ephemeris data and GNSS based on ephemeris data mode and UE mobility mode.
* Option 2: (Xiaomi, CMCC)
  + The UE specific TA estimation error is consist of the accuracy of A-GNSS position estimation (ΔUE-pos) and the accuracy of serving-satellite ephemeris (ΔSat-pos).
  + The UE specific TA estimation accuracy is defined as 10Ts.
* Option 3: (CMCC)
  + In order to measure the UE specific TA accuracy, take the following assumptions as the starting point:
    - For GNSS accuracy, take 50m as the worst case and 20m as the typical case;
    - For PVT accuracy, take the precise PVT information as the starting point, and further update after RAN1 achieving the conclusion.
* Option 4: (Apple)
  + UE specific TA estimation accuracy is 20.5\*64\*Tc + Tephemeris\_uncertainty. Tephemeris\_uncertainty is the satellite position error due to ephemeris information and UE calculation.
* Option 5: (Ericsson)
  + Use existing UE initial transmit timing error, Te also for NTN as UE specific estimation accuracy for initial access.
* Option 6: (THALES)
  + For PRACH transmission, the NR NTN UE shall be able to self-estimate its with an accuracy better than ± ,  depending on the PRACH format and configuration.
  + Proposal 10: In connected mode, the NR NTN UE shall be able to self-estimate its with an accuracy better than ±  depending on the numerology in use.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-1-3: Whether to define the update periodicity for UE specific TA estimation?**

* Option 1: (Intel, CMCC, Ericsson)
  + Yes
* Option 2: (CATT, Xiaomi, Apple, Huawei, MTK, Qualcomm, ZTE, THALES)
  + No
* Option : (LGE)
  + Under discussion in RAN1

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.
* Companies are encouraged to double check whether this issue is discussing in RAN1.

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**Issue 1-1-4: UE behaviour related to UE specific TA estimation**

* Option 1: (CATT, CMCC)
  + Defer discussion for specifying UE behaviour related to UE specific TA estimation, and wait RAN1 conclusion.
* Option 2: (THALES, Ericsson, Intel)
  + Specify UE behaviour related to the combination of UE specific TA estimation () and self-estimated TA common ().
* Option 3 (Apple, Xiaomi, Huawei, Qualcomm, ZTE):
  + No need to define UE behavior for UE specific TA estimation as a requirement, as long as UE can meet the timing requirement, i.e., Te/Tq/Tp.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-1-5: GNSS related accuracy**

* Option 1: (CATT, THALES)
  + RAN4 should confirm the accuracy of ephemeris data and accuracy of UE PVT from satellite system and GNSS system, and confirm the accuracy of extrapolation from ephemeris data and GNSS based on ephemeris data mode and UE mobility mode.
* Option 2: (Nokia, Ericsson)
  + RAN4 should discuss how a UE can determine it accuracy from GNSS is accurate enough to fulfil the initial transmission timing error requirements.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-1-6: UE specific TA estimation requirement for UE specific TA pre-compensation reporting**

Tentative agreement in 1st round discussion:

Wait RAN1/RAN2 conclusions on UE specific TA pre-compensation reporting to determine whether we need to define separate UE specific TA estimation requirement or not.

*Recommendations for 2nd round:*

* Companies are double check whether option 1 is agreeable or not.

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**Issue 1-1-7: whether to define a separate accuracy requirement for self-estimated TA common ()?**

* Option 1: (THALES, Ericsson)
  + Yes.
* Option 1: (Apple, Xiaomi, Huawei, Qualcomm, CATT, CMCC)
  + No.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-1-8: If yes for issue 1-7, the accuracy requirement for self-estimated TA common ()?**

* Option 1: (THALES)
  + For PRACH transmission, the NR NTN UE shall be able to self-estimate with an accuracy better than ± ,  depending on the PRACH format and configuration.
  + In connected mode, the NR NTN UE shall be able to self-estimate with an accuracy better than ±  depending on the numerology in use.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-1-9: whether to define a separate accuracy requirement for the combination of ?**

* Option 1: (THALES, Ericsson)
  + Yes.
* Option 1: (Apple, Xiaomi, Huawei, Qualcomm, CATT)
  + No.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-1-10: If yes for issue 1-9 the accuracy requirement for self-estimated TA common ()?**

* Option 1: (THALES)
  + For PRACH transmission, the NR NTN UE shall be able to self-estimate with an accuracy better than ± ,  depending on the PRACH format and configuration.
  + In connected mode, the NR NTN UE shall be able to self-estimate with an accuracy better than ±  depending on the numerology in use.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-1-11: Whether UE should use the referenceTimeInfo-R16 and GNSS-provided time reference to calculate TA at the UE.**

* Option 1: (Nokia, Apple)
  + FFS
    - RAN4 should discuss whether the use os the time provided by referenceTimeInfo-R16 is beneficial to securing that the initial transmission timings are kept by a UE.
* Option 1: (Xiaomi, Huawei, Qualcomm, CATT, Ericsson, ZTE THALES)
  + Up to RAB1/RAN2 decision

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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#### UE transmit timing requirements

**Issue 1-2-1: The composites should be considered for initial transmit timing requirement in NTN (Te\_NTN).**

* Option 1: (QC, Xiaomi, Huawei, LGE, ZTE, NEC, CMCC)
  + UE position estimation error
  + Serving-satellite position estimation error
  + The current UE transmit timing error requirement
* Option 1a: (LGE, MTK, Huawei, ZTE)
  + GNSS inaccuracy
  + The current UE transmit timing error requirement
* Option 2: (Apple)
  + legacy Te
  + UE specific TA estimation error (without ephemeris uncertainty)
* Option 3: (THALES, Ericsson)
  + The accuracy of UE specific TA estimation (N\_(TA,UE-specific)) and self-estimated TA common (N\_(TA,common)) is counted into the UE transmit timing error requirement.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.
* Companies are encouraged to provide views on whether the satellite ephemeris error should be accounted in Te requirement.

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**Issue 1-2-2: Whether A-GNSS requirements of TS38.171 can be referred for Te\_NTN requirement.**

* Option 1: (Apple, Huawei, QC, CATT, ZTE, THALES, CMCC)
  + Yes
* Option 2: (QC, Xiaomi, Ericsson)
  + No

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.
* Companies are encouraged to provide views on which requirement in TS38.171 can be used as a reference.

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**Issue 1-2-3: GNSS position error assumption for Te\_NTN requirement.**

* Option 1: (QC)
  + at least 50m, and further relax up to 100m
* Option 2: (Xiaomi, CATT, THALES)
  + 50m
* Option 3: (CMCC, CATT)
  + 50m as the worst case and 20m as the typical case
* Option 4: (MTK, Xiaomi, THALES, NEC, Intel)
  + For UL SCS of 15/30 kHz: <= 50 m
  + For UL SCS of 60/120 kHz: <= 30 m
* Option 5: (Apple, LGE, Nokia)
  + The worst case: 100m

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.
* Companies are encouraged to provide views on whether 50m of GNSS position error can be assumed as a starting point.

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**Issue 1-2-4: Whether to define general GNSS positioning accuracy requirements?**

* Option 1: (Huawei, Ericsson, Nokia, THALES)
  + Yes, it is suggested to define general GNSS positioning accuracy requirements which can be referred for deriving other RRM requirements.
* Option 2: ()
  + FFS

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-2-5: Initial transmit timing error (Te\_NTN)**

* Option 1: (QC)
  + NTN UE initial timing error requirements should be relaxed to account for at least 50m of a composite position estimation error.
    - For FR1 NTN UE in RRC Connected state, the requirement should be further relaxed to accommodate a composite position estimation error up to 100ms.
* **Table 3: T’e Timing Error Limit when a total UE positioning error is allowed up to 50m**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Frequency Range | SCS of SSB signals [kHz] | SCS of uplink signals [kHz] | Te | Te [us] | max(Tch) [us] | max(Tch)/Tcp [%] | Max(T’e) |
| 1 | 15 | 15 | 12\*64\*Tc | 0.39 | 3.57 | 76 | 17\*64\*Tc |
|  |  | 30 | 10\*64\*Tc | 0.33 | 1.35 | 58 | 15\*64\*Tc |
|  |  | 60 | 10\*64\*Tc | 0.33 | 0.17 | 15 | 15\*64\*Tc |
|  | 30 | 15 | 8\*64\*Tc | 0.26 | 3.83 | 82 | 13\*64\*Tc |
|  |  | 30 | 8\*64\*Tc | 0.26 | 1.49 | 64 | 13\*64\*Tc |
|  |  | 60 | 7\*64\*Tc | 0.23 | 0.38 | 32 | 12\*64\*Tc |
| 2 | 120 | 60 | 3.5\*64\*Tc | 0.11 | 0.62 | 53 | 8.5\*64\*Tc |
|  |  | 120 | 3.5\*64\*Tc | 0.11 | 0.03 | 6 | 8.5\*64\*Tc |
|  | 240 | 60 | 3\*64\*Tc | 0.098 | 0.64 | 55 | 8\*64\*Tc |
|  |  | 120 | 3\*64\*Tc | 0.098 | 0.06 | 10 | 8\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 | | | | | | |  |

**Table 4: T’e Timing Error Limit when a total UE positioning error is allowed up to 100m**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Frequency Range | SCS of SSB signals [kHz] | SCS of uplink signals [kHz] | Te | Te [us] | max(Tch) [us] | max(Tch)/Tcp [%] | Max(T’e) |
| 1 | 15 | 15 | 12\*64\*Tc | 0.39 | 3.24 | 72 | 22\*64\*Tc |
|  |  | 30 | 10\*64\*Tc | 0.33 | 1.02 | 66 | 20\*64\*Tc |
|  | 30 | 15 | 8\*64\*Tc | 0.26 | 3.5 | 75 | 18\*64\*Tc |
|  |  | 30 | 8\*64\*Tc | 0.26 | 1.16 | 49 | 18\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 | | | | | | |  |

* Option 2: (CATT)
  + The NTN UE initial transmit timing error should be relaxed, and may be relaxed to [1/10]CP ~ [1/2]CP for different SCS. The relaxed part is allowed for NTN UE specific estimation accuracy.
* Option 3: (Xiaomi)
  + The Te requirement in NTN is shown in table 1.

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| Frequency Range | SCS of SSB signals [kHz] | SCS of uplink signals [kHz] | Te | UE specific TA estimation accuracy | Te\_NTN |
| 1 | 15 | 15 | 12\*64\*Tc | 10Ts | 22\*64\*Tc |
|  |  | 30 | 10\*64\*Tc | 10Ts | 20\*64\*Tc |
|  |  | 60 | 10\*64\*Tc | 10Ts | 18\*64\*Tc |
|  | 30 | 15 | 8\*64\*Tc | 10Ts | 18\*64\*Tc |
|  |  | 30 | 8\*64\*Tc | 10Ts | 18\*64\*Tc |
|  |  | 60 | 7\*64\*Tc | 10Ts | 15\*64\*Tc |
| 2 | 120 | 60 | 3.5\*64\*Tc | 10Ts | 10\*64\*Tc |
|  |  | 120 | 3.5\*64\*Tc | 10Ts | 10\*64\*Tc |
|  | 240 | 60 | 3\*64\*Tc | 10Ts | 8\*64\*Tc |
|  |  | 120 | 3\*64\*Tc | 10Ts | 8\*64\*Tc |

**Table 1: Te requirement in NTN**

* Option 4: (CMCC)
  + The revisited Te requirement for NTN can take the following tables as the baseline. Further update the values in bracket squares after achieving the conclusions about GNSS accuracy and PVT accuracy.

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| **Frequency Range** | **SCS of SSB signals (kHz)** | **SCS of uplink signals (kHz)** | **Te (worst-case)** |
| 1 | 15 | 15 | (12+[5])\*64\*Tc=[17]\*64\*Tc |
|  |  | 30 | [15]\*64\*Tc |
|  |  | 60 | [15]\*64\*Tc |
|  | 30 | 15 | [13]\*64\*Tc |
|  |  | 30 | [13]\*64\*Tc |
|  |  | 60 | [12]\*64\*Tc |
| 2 | 120 | 60 | [8.5]\*64\*Tc |
|  |  | 120 | [8.5]\*64\*Tc |
|  | 240 | 60 | [8]\*64\*Tc |
|  |  | 120 | [8]\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 [6] | | | |

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| **Frequency Range** | **SCS of SSB signals (kHz)** | **SCS of uplink signals (kHz)** | **Te(typical-case)** |
| 1 | 15 | 15 | (12+[2])\*64\*Tc=[14]\*64\*Tc |
|  |  | 30 | [12]\*64\*Tc |
|  |  | 60 | [12]\*64\*Tc |
|  | 30 | 15 | [10]\*64\*Tc |
|  |  | 30 | [10]\*64\*Tc |
|  |  | 60 | [9]\*64\*Tc |
| 2 | 120 | 60 | [5.5]\*64\*Tc |
|  |  | 120 | [5.5]\*64\*Tc |
|  | 240 | 60 | [5]\*64\*Tc |
|  |  | 120 | [5]\*64\*Tc |
| Note 1: Tc is the basic timing unit defined in TS 38.211 [6] | | | |

* Option 5: (ZTE, THALES)
  + Reuse the existing Te requirements defined in TS 38.133.
* Option 6: (NEC)
  + RAN4 to further wait for RAN1 progress to define the Te requirements and possible relaxations compared to NR initial timing error requirements.
* Option 7: (Huawei)
  + The UE initial transmit timing error requirements for NTN network can be defined as (Te + Tpos), where Te is same as the existing Te requirements in TS38.133 and Tpos is defined as the timing error derived from GNSS positioning error.
* Option 8: (Ericsson)
  + Te\_NTN = 2\*Te
* Option 9: (Apple)
  + The NTN Te requirement with relaxation shall not exceed (half CP – 8\*64\*Tc) for FR1 and half CP for FR2 on UL.
  + When ephemeris information is used to derive UE specific TA in Te requirement, the error due to ephemeris uncertainty shall not be considered.
  + The Te requirement for NTN is defined by:
    - FR1 NTN Te requirement: min{(legacy Te + 20.5\*64\*Tc), (half CP – 8\*64\*Tc)}
    - FR2 NTN Te requirement: min{(legacy Te + 20.5\*64\*Tc), half CP }

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| *Frequency Range* | *SCS of SSB signals (kHz)* | *SCS of uplink signals (kHz)* | *Te for NTN* | Note |
| *1* | *15* | *15* | *32.5\*64\*Tc* | *min{(legacy Te + 20.5\*64\*Tc), (half CP – 8\*64\*Tc)}*  *note: 60kHz FR1 Te is not smaller than FR2 60kHz Te* |
|  |  | *30* | *28\*64\*Tc* |
|  |  | *60* | *18\*64\*Tc* |
|  | *30* | *15* | *32.5\*64\*Tc* |
|  |  | *30* | *28\*64\*Tc* |
|  |  | *60* | *18\*64\*Tc* |
| *2* | *120* | *60* | *18\*64\*Tc* | *min{(legacy Te + 20.5\*64\*Tc), half CP }* |
|  |  | *120* | *9\*64\*Tc* |
|  | *240* | *60* | *18\*64\*Tc* |
|  |  | *120* | *9\*64\*Tc* |

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-2-6: Whether define different gradual timing adjustment requirements for different NTN topologies** **e.g. GEO, MEO, LEO.**

* Option 1: (CATT, Xiaomi, Ericsson)
  + Yes
* Option 2: (QC, CMCC, Apple, Huawei, ZTE, THALES, NEC, CMCC, Intel)
  + FFS

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-2-7: Which assumptions will be used to define gradual timing adjustment requirements for NTN network?**

* Option 1: (Huawei)
  + Assumption 1: UE performs timing adjustment for downlink reception timing drifting and UE specific TA change separately. (Huawei, MTK, Ericsson)
  + Assumption 2: UE performs timing adjustment with combining downlink reception timing drifting and UE specific TA change as one adjustment. (Huawei, Apple, QC, THALES, CMCC, Intel)

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-2-8: Whether the maximum delay variation should be considered in the gradual timing adjustment requirement in NTN?**

* Option 1: (Xiaomi, CMCC, Ericsson, Apple, Huawei, QC, Ericsson)
  + Yes
* Option 2: (CATT, MTK, THALES, NEC)
  + FFS.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-2-9: Whether to define new gradual timing adjustment requirements for NTN network?**

Tentative agreement in first round discussion:

RAN4 to introduce new gradual timing adjustment requirements for NTN network.

*Recommendations for 2nd round:*

* Companies are encouraged to double check the tentative agreement.

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**Issue 1-2-10: Gradual timing adjustment requirement**

* Option 1: (CATT)
  + The Tq and Tp in TN system can be reused. But the maximum aggregate adjustment rate will be defined based on different NTN topologies, such as Tq per [20] ms for LEO600km cell, but Tq per [60]s for GEO.
* Option 2: (Xiaomi)
  + The maximum amount of the magnitude of the timing change in one adjustment shall be Tq\_NTN = 25\*Ts.
  + The minimum aggregate adjustment rate shall be Tp\_NTN = 100Ts per 100ms.
  + The maximum aggregate adjustment rate shall be Tq\_NTN = 25\*Ts per 20 ms.The Tq and Tp can be reused. The maximum aggregate adjustment rate should be Tq per 20ms.
* Option 3: (CMCC)
  + In FR1, The maximum aggregate adjustment rate shall be Tq per Xms, Tq value use [255/200\*X]\*64\*Tc as the baseline, a candidate set of X can be [50ms, 40ms, 20ms], the specific value can be further discussed
* Option 4: (Ericsson)
  + The parameter Tq will have to be modified. For a period of 200 ms we could have a worst case delay variation of 246 \* 64 Tc.
  + Either the period has to be shortened from 200 ms to something smaller, or we need to increase Tq.
* Option 5: (Apple)
  + the design principle for gradual timing adjustment requirement is:
    - Tp=Tq
    - Where,
      * Tdrift is the UE time drifting during 200ms;
      * Vrelative is the relative speed between UE and satellite
      * T\_granularity is the UE UL timing granularity
      * digRF\_margin is the margin for digital RF, i.e., 1.5\*64\*Tc.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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| **Company** | **Comments** |
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**Issue 1-2-11: In GEO scenarios, whether the existing gradual timing adjustment requirement can be applied**

* Option 1: (Xiaomi, CMCC)
  + Yes
* Option 2: (Apple, QC, CATT, Ericsson, ZTE, THALES)
  + FFS
* Option 3: (NEC)
  + No

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-2-12: The direction of timing adjustment for NTN UE pre-compensation.**

* Option 1: (MTK)
  + The timing adjustment of NTN UE pre-compensation and TN gradual timing adjustment are in opposite directions
  + Legacy gradual timing adjustment cannot directly reused. The direction of timing adjustment for NTN UE pre-compensation should be further clarified in the requirement.
* Option 2: (Intel)
  + 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.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-2-13: The reference timing for UE transmit timing.**

* Option 1: (THALES, Ericsson, NEC)
  + The time reference for the UE transmit timing control requirement shall be the downlink timing of the reference cell minus . Therefore, the UE transmit timing error requirement does not cover the self-TA estimation errors.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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#### TA adjustment accuracy requirements

**Issue 1-3-1: Whether to define TA adjustment accuracy requirement in RRC\_IDLE mode**

Tentative agreement in 1st round discussion:

Not define TA adjustment accuracy requirement in RRC\_IDLE mode.

*Recommendations for 2nd round:*

* Companies are encouraged to double check the tentative agreement.

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**Issue 1-3-2: Whether the UE position and satellite position estimation error should be accounted for TA adjustment accuracy requirement?**

* Option 1: (Xiaomi, LGE, Nokia)
  + Yes
* Option 2: (QC, CMCC, LGE, CATT, CMCC)
  + Depends on RAN1 design
* Option 2: (Apple, Huawei, NEC)
  + No

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-3-3: TA adjustment accuracy requirement in RRC\_CONNECTED mode**

* Option 1: (NEC, Huawei, Ericsson, Apple, MTK, NEC)
  + Reuse the existing timing advance adjustment accuracy requirements defined in TS 38.133.
* Option 1a: (NEC)
  + RAN4 to reuse the existing TA adjustment accuracy requirement defined in TS 38.133 with considering of UL timing quantization accuracy.
* Option 2: (Xiaomi, CMCC, LGE)
  + RAN4 is to define a relaxed TA adjustment accuracy requirement for NR NTN
* Option 2a: (QC)
  + Request RAN1 whether and how to reflect a propagation delay change, i.e. open loop TA update, from a slot when UE received timing advance command to a slot when the indicated timing advance shall be applied to uplink transmission. If defined, depending on RAN1 design NTN UE timing advance adjustment accuracy requirements may have to be relaxed to account for UE position and satellite position estimation error. And if it is decided to relax the requirement, the accuracy requirement relaxation shall be the same as that for initial timing error requirement.

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-3-4: UE behaviour before applying timing advance adjustment for its uplink transmission.**

* Option 1: (LGE)
  + UE specific TA should be updated in the slot before applying timing advance adjustment for its uplink transmission
* Option 2: (Xiaomi, QC, Intel)
  + FFS
* Option 3: (Apple, Huawei, MTK, THALES)
  + Up to UE implementation

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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**Issue 1-3-5: Open and closed loop for TA adjustment.**

* Option 1: (Intel, Apple, ZTE, NEC)
  + Open and close loop specific timing requirements are pending other WG discussions.
* Option 2: (QC, Nokia, Ericsson, THALES)
  + RAN4 to set requirements on how open loop TA control in RRC connected mode should be applied in a way that does not impact the closed loop TA control messages. (Nokia)
  + RAN4 to investigate whether there is any issue due to a conflict between UE specific TA update periodicity, i.e. open loop TA update, and Network controlled close loop TA update, hence, explicitly resolution and/or spec handling. (QC)

*Recommendations for 2nd round:*

* Continue the discussion in the 2nd round.

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# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on timing requirements for NR NTN | Xiaomi |  |
| LS on … | ZZZ | To: RAN\_X; Cc: RAN\_Y |
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**Existing tdocs**

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

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| **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 |  |
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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