**3GPP TSG RAN WG1 Meeting #112bis-e R1-2303911**

**e-Meeting, April 17th – April 26th, 2023**

**Agenda Item: 9.9.4**

**Source: Moderator (MediaTek)**

**Title: Feature lead summary #1** **of AI 9.9.4 on improved GNSS operations**

**Document for: Discussion**

# 0 Introduction

[112bis-e-R18-NTN-04] Email discussion on improved GNSS operations for IoT NTN – Wen (MediaTek)

* Check points: April 21, April 26

## 0.1 Background

In RAN#98e, the revised WID on IoT NTN enhancements has been endorsed for Release 18 [1].

The work item aims to specify further enhancements for E-UTRA (LTE-RAN) based NTN (non-terrestrial networks) according to the following assumptions:

- GEO and NGSO (LEO and MEO).

- Earth fixed Tracking area. Earth fixed & Earth moving cells for NGSO

- FDD mode

- UEs with GNSS capabilities

The detailed objectives are to specify enhanced NB-IoT NTN and eMTC NTN radio interfaces and E-UTRAN/NG-RAN as follows:

4.1.1 IoT-NTN Performance Enhancements in Rel-18 to address remaining issues from Rel-17

This work considers Rel-17 IoT-NTN as baseline as well as Rel-17 NR-NTN outcome and the further IoT-NTN performance enhancements objectives are listed below:

- Disabling of HARQ feedback to mitigate impact of HARQ stalling on UE data rates [RAN1,RAN2]

- Study and specify needed improved GNSS operations for a new position fix for UE pre-compensation during long connection times and for reduced power consumption. Simultaneous GNSS and NTN NB-IoT/eMTC operation is not assumed. [RAN1, RAN2]

* *NOTE: The need for RAN4 Core requirements for this objective will be identified after the conclusion on the need for improvements.*

In this meeting, company views on improved GNSS operations for IoT NTN are summarized and proposals on identified issues are made.

## 0.2 Contact Information

Please help to fill in the contact information for the FL summary. (If any change, please revise.)

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# [Active] Issue #1: GNSS validity duration extension and potential enhancements

**Agreement (RAN1 106e):**

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 IoT-NTN

**Agreement (RAN1 109e):**

Closed loop time and frequency correction, with potential enhancements, for IoT-NTN is considered to reduce the need for UE to update GNSS position fix in long connection time

**Agreement (RAN1 112):**

At least for the case when frequency error is within frequency error requirements, study the mechanisms and conditions to allow UL transmission after original GNSS validity duration expires without GNSS re-acquisition for some duration.

* FFS: with legacy closed loop time correction or enhanced closed loop time correction
* This mechanism is enabled/configured by eNB
* FFS: whether such mechanism will be specified depends on the outcome of this study

## Company contributing views

|  |  |
| --- | --- |
| Contribution | Observation/Proposals |
| Huawei, HiSilicon | Observation 1: Further enhancement on the Close loop time and frequency error correction is not needed during the connection for IoT NTN.Proposal 7: When GNSS validity duration expires, UE is still allowed to transmit UL when timeAlignmentTimer corresponding to a TAC is running. |
| Spreadtrum | Proposal 3: If the frequency error is within frequency error requirements and the timing error is also within timing error requirements, or the timing error can be adjusted through the existing closed-loop adjustment mechanism, then UE can also perform UL transmission after original GNSS validity duration expires without GNSS re-acquisition for some duration.Proposal 4: legacy closed loop time correction does not need to be enhanced. |
| CATT | Proposal 7: It is not necessary to support UL transmission after original GNSS validity duration expires without GNSS re-acquisition |
| NEC | Proposal 1: Closed-loop correction during long UL repetition is not needed for IoT NTN. |
| Nokia, NSB | Observation 8: There may be a need for a GNSS measurement during a long period of downlink/uplink repetitions.Proposal 8: RAN1 to discuss handling a GNSS measurement during a long period of downlink/uplink repetitions.Observation 9: the eNB may detect that the UE’s uplink transmission is well aligned despite the GNSS validity duration expiry is approaching.Proposal 9: the eNB can extend the GNSS validity duration (allow the UL transmission after expiry of the original GNSS validity duration) and rely on the legacy framework for closed loop time correction. |
| Xiaomi | Proposal 6: Closed loop frequency control can be supported to avoid frequent GNSS measurement. |
| Samsung | Proposal 1: Support closed loop correction for pre-compensated frequency offset, e.g., absolute frequency command and/or frequency adjustment command can be considered. |
| Nordic | Proposal 1: In RRC connected mode, the closed loop time and frequency correction loops could be considered as a complementary mechanism to GNSS gaps. |
| ZTE | Proposal 8: When closed loop time correction is used to maintain UL synchronization after expiry of original GNSS validity duration, eNB will indicate an extension of GNSS validity duration to UE.* The GNSS validity duration of current GNSS position fix should be the sum of original GNSS validity duration and the extension indicated by eNB.
* The behaviors upon expiration of GNSS validity duration will keep unchanged no matter whether it is extended by eNB or not.
 |
| MediaTek | Proposal 1: For Rel-18 long connection transmission, if GNSS validity duration expires while timeAlignmentTimer has not expired, UE can be allowed to have UL transmission without GNSS re-acquisition. |
| Ericsson | Observation 1: The existing TAC mechanism is sufficient to address the timing error due to incorrect UE position in IoT NTN.Proposal 1: eNB to indicate a time duration X to an IoT NTN UE in connected mode such that the UE can continue its uplink transmission for a time duration X after GNSS validity duration has expired.Proposal 2: Network to optionally indicate UE-specific timing drift parameters to an IoT NTN UE in connected mode. Proposal 3: Upon GNSS position expiry in connected mode, an IoT NTN UE to use UE-specific drift information (in addition to common TA parameters) to calculate TA values before receiving the next TA command. Proposal 4: Closed loop frequency correction mechanism shall not be specified unless absolutely necessary. |
| Qualcomm | Proposal 1: For the objective on improved GNSS operations and reduced power consumption, the following framework is followed by RAN1:1. Specify closed-loop time enhancements to increase the connection duration between consecutive GNSS re-acquisitions.
2. Specify aperiodic eNB triggers to instruct the UE to re-acquire GNSS (already agreed).
3. Specify a mechanism for the UE to re-acquire GNSS upon expiry of the GNSS validity (already agreed).

Observation 1: For long connections in eMTC and NB-IoT over NTN, closed-loop time and frequency corrections lowers the GNSS power penalty from $45\%$ to $17\%$ (with a GNSS relaxation factor of 4), w.r.t a baseline without closed-loop corrections.Proposal 8: RAN1 to specify enhancements to closed-loop corrections to mitigate UE power consumption at least for the case where the frequency errors are not the limiting factor.* If closed loop corrections are used, the UE is allowed to perform UL transmission after original GNSS validity duration expires. FFS: exact mechanism

Observation 2: According to current specifications, any time a UE transmits a NPRACH, it uses a value of $N\_{TA}=0$.Observation 3: If a considerable amount of time has passed since the last GNSS position fix, e.g., for a mobile UE, the accuracy of $N\_{TA, adj}^{UE}$ becomes progressively worse over time.Observation 4: Although the eNB can progressively correct (by issuing TA commands) the timing error due to a stale UE location, this correction is not applied when transmitting NPRACH (which currently uses $N\_{TA}=0)$. This may cause the timing error to go beyond the NPRACH correction capability.Proposal 9: RAN1 to specify solutions such that closed loop TA commands can also applied to NPRACH. Candidate solutions include:* Updating the $N\_{TA, adj}^{UE}$ term with every TA command received in response to transmitting a NPRACH in connected mode
* Accumulating prior TA commands into the $N\_{TA}$ term, as opposed to setting it to 0 for a NPRACH transmission
 |
| Lenovo | Proposal 1：Considering the workload and standard effort, it is better not to support of closed loop time and frequency correction enhancement during long connection. |

In RAN1 #112 meeting, RAN1 has agreed that at least for the case when frequency error is within frequency error requirements, study the mechanisms and conditions to allow UL transmission after original GNSS validity duration expires without GNSS re-acquisition for some duration. The duration for UL transmission after GNSS validity duration expires can be understood as GNSS validity duration extension. GNSS validity duration extension and potential enhancements are discussed by contributing companies.

1. **Closed loop time correction wi/o potential closed loop frequency correction:**

Huawei, HiSilicon, Spreadtrum, ZTE preferred no further enhancements on legacy closed loop time correction are needed

* Huawei, HiSilicon illustrate the timing and frequency error as well as the corresponding requirement (i.e. 80Ts and 200Hz(0.1ppm@2GHz)) with different UE speeds for the scenario in Figure 3 in R1-2302367 and observed that further enhancement on the Close loop time and frequency error correction is not needed.



(a)



 (b) (c)

**Figure 3 (a) Scenario when evaluated Doppler shift by using old UE location is opposite to the real Doppler shift; (b) Timing error with different UE speeds (c) Frequency error with different UE speeds**

* Xiaomi illustrated the time and frequency error caused by inaccurate UE GNSS location in figure 1 and figure 2 from R1-2303001 respectively. And Xiaomi commented GNSS measurement consumes a large portion of the IoT UE’s battery and frequent GNSS measurement should be avoid. For the TA error, the closed loop TA adjustment has already been supported in the legacy design.



Figure 1: TA error due to the UE movement



Figure 2: Doppler shift due to the UE movement

* ZTE mentioned to simplify the implementation, it is preferred to reuse current closed loop time correction mechanism and enhance the GNSS validity duration only.
* Ericsson mentioned assuming a worst-case TA error of 12\*Ts due to satellite motion at the end of a transmission segment, there remains 5\*Ts (0.16 $μ$s) to account for the TA error due to UE mobility. Without closed loop timing correction, Table 1 from R1-2303432 shows that for 3 km/h, the UE may need to correct its timing to account for TA error due to UE mobility either via a TA command (TAC) or by refreshing its GNSS after 34 s. At 120 km/h, such an intervention will be needed every 0.83 s. Ericsson observed the existing TAC mechanism is sufficient to address the timing error due to incorrect UE position in IoT NTN.

Table 1 Impact of UE mobility on timing error requirements for eMTC NTN.

|  |  |  |  |
| --- | --- | --- | --- |
| UE speed | TA error rate due to UE mobility only | TA error due to satellite’s motion only | Time to reach the timing error limit of 17\*Ts |
| 3 km/h | 0.00467 $μ$s/s | 0.39 $μ$s | 34.3 s |
| 60 km/h | 0.0967 $μ$s/s | 0.39 $μ$s | 1.65 s |
| 120 km/h | 0.193 $μ$s/s | * 1. $μ$s
 |  |

* Qualcomm mentioned based on transmission of an uplink signal (e.g. (N)PUSCH, (N)PRACH), the network estimates the observed time and/or frequency error and the network issues closed-loop commands for the UE to adjust its transmission time and/or frequency. With these closed-loop corrections, the UE can skip a GNSS fix and keep operating with acceptable time and frequency errors as depicted in Fig. 1 and demonstrate how the power penalty due to GNSS fixes diminishes with an increase in the GNSS relaxation factor, which essentially denotes the factor by which we reduce the total number of GNSS fixes required and replace it with adequate close-loop corrections In Table 1 of R1-2303609.



Figure 1: Relaxed GNSS fixing using closed loop corrections.

Table 1: Reduction in power penalty due to GNSS, by relaxing required GNSS fixes and enabling NPRACH-driven closed-loop time and frequency corrections.

|  |  |
| --- | --- |
| GNSS Relaxation factor | Power penalty due to GNSS in connected mode for long connections |
| No Relaxation | $$45\%$$ |
| 2 | $$29\%$$ |
| 4 | $$17\%$$ |

Table 1 the comments on Closed loop frequency correction

|  |  |  |  |
| --- | --- | --- | --- |
| Contribution | Support | Not support | View |
| Huawei, HiSilicon |  | × | The validity time based on the frequency error requirement is much larger than that based on the timing error requirement where in most cases, the frequency error will not exceed the frequency error requirement. |
| NEC |  | × | It is not necessary to spend standardisation efforts on specifying enhancements for closed loop frequency correction and it is not possible to receive signalling timely when long UL repetition is configured. |
| Xiaomi | √ |  | For 120Km/h UE movement, the Doppler shit may be an issue at least for the case with higher elevation angle and some IoT UE may not be able to perform GNSS measurement in RRC-connected mode where they have to rely on the closed loop control to maintain a long connection. |
| Nordic Semiconductor ASA | √ |  | In RRC connected mode, the closed loop time and frequency correction loops could be considered as a complementary mechanism to GNSS gaps. |
| Samsung | √ |  | Introducing a closed loop frequency control signaling is needed to reduce the times of acquiring a new GNSS position fix during a long connection time and improve UE battery life, e.g., using a MAC CE to indicate frequency command.  |
| Ericsson |  | × | Closed loop frequency correction mechanism shall not be specified unless absolutely necessary |
| Qualcomm | √ |  | For long connections in eMTC and NB-IoT over NTN, closed-loop time and frequency corrections lowers the GNSS power penalty from 45% to 17% (with a GNSS relaxation factor of 4), w.r.t a baseline without closed-loop correction.  |
| Lenovo |  | × | Closed loop frequency correction may involve some evaluations and requirements for RAN4 (e.g., frequency correction granularity, frequency correction range, accuracy requirement), the workload of WI may be reevaluated |

1. **Other potential enhancements:**

Contributing companies mentioned serval potential enhancements to reduce the need for UE to update GNSS position fix in long connection time as follows:

* Ericsson proposed Network to optionally indicate UE-specific timing drift parameters to an IoT NTN UE in connected mode. Ericsson further proposed upon GNSS position expiry in connected mode, an IoT NTN UE to use UE-specific drift information (in addition to common TA parameters) to calculate TA values before receiving the next TA command.
* Qualcomm observed that According to current specifications, any time a UE transmits a NPRACH, it uses a value of $N\_{TA}=0$ and if a considerable amount of time has passed since the last GNSS position fix the accuracy of $N\_{TA, adj}^{UE}$ becomes progressively worse over time, and although the eNB can progressively correct (by issuing TA commands) the timing error due to a stale UE location, this correction is not applied when transmitting NPRACH (which currently uses $N\_{TA}=0)$. This may cause the timing error to go beyond the NPRACH correction capability. Qualcomm proposed to specify solutions such that closed loop TA commands can also applied to NPRACH. Candidate solutions include:
	+ Updating the $N\_{TA, adj}^{UE}$ term with every TA command received in response to transmitting a NPRACH in connected mode
	+ Accumulating prior TA commands into the $N\_{TA}$ term, as opposed to universally setting it to 0 for a NPRACH transmission
1. **On GNSS validity duration extension:**

Huawei, HiSilicon, Spreadtrum, Nokia, NSB, ZTE, MediaTek, Ericsson, Qualcomm preferred UL transmission can be allowed after original GNSS validity duration expires without GNSS re-acquisition for some duration.

CATT preferred it is not necessary to support UL transmission after original GNSS validity duration expires without GNSS re-acquisition.

* Huawei, HiSilicon proposed when GNSS validity duration expires, UE is still allowed to transmit UL when timeAlignmentTimer corresponding to a TAC is running. Huawei, HiSilicon mentioned during the connection, the eNB can detect the UL time error and sent the closed loop TAC to the UE for TA adjustment and the TA error caused by UE’s movement can be partially corrected by the closed loop TAC and UL transmission is still possible even if the reported GNSS validity expires as illustrated in Fig.2 of R1-2302367.



**Figure 2 UL transmission after GNSS validity duration expires**

* Spreadtrum proposed If the frequency error is within frequency error requirements and the timing error is also within timing error requirements, or the timing error can be adjusted through the existing closed-loop adjustment mechanism, then UE can also perform UL transmission after original GNSS validity duration expires without GNSS re-acquisition for some duration.
* Nokia, NSB observed that there may be a need for a GNSS measurement during a long period of downlink/uplink repetitions and proposed RAN1 to discuss handling a GNSS measurement during a long period of downlink/uplink repetitions.Nokia, NSB commented it can be discussed whether the eNB instead of triggering the UE to perform a new GNSS measurement can command the UE to extend the GNSS validity duration timer. Nokia, NSB further observed the eNB may detect that the UE’s uplink transmission is well aligned despite the GNSS validity duration expiry is approaching and proposed the eNB can extend the GNSS validity duration (allow the UL transmission after expiry of the original GNSS validity duration) and rely on the legacy framework for closed loop time correction.
* ZTE mentioned when closed loop time correction is used to maintain UL synchronization after expiry of original GNSS validity duration, eNB will indicate an extension of GNSS validity duration to UE and the GNSS validity duration of current GNSS position fix should be the sum of original GNSS validity duration and the extension indicated by eNB, where the behaviors upon expiration of GNSS validity duration will keep unchanged no matter whether it is extended by eNB or not.
* MediaTek mentioned there is timeAlignmentTimer (TAT) which is used to control how long the MAC entity considers the Serving Cells belonging to the associated TAG to be uplink time aligned. Value of TimeAlignmentTimer in RRC connected is configured in number of sub-frames as in TS 36.331 with {sf500, sf750, sf1280, sf1920, sf2560, sf5120, sf10240, infinity}. Besides, RAN2 assumes Upon recovery from loss of precomp synch while TAT has not expired, UE resumes UL operation, no RACH is needed in Rel-17. MediaTek further proposed that for Rel-18 long connection transmission, if GNSS validity duration expires while timeAlignmentTimer has not expired, UE can be allowed to have UL transmission without GNSS re-acquisition.
* Ericsson proposed eNB to indicate a time duration X to an IoT NTN UE in connected mode such that the UE can continue its uplink transmission for a time duration X after GNSS validity duration has expired.
* Qualcomm mentioned if closed loop corrections are used, the UE is allowed to perform UL transmission after original GNSS validity duration expires.

Moderator View: In RAN1 112, it has been agreed to study the mechanisms and conditions to allow UL transmission after original GNSS validity duration expires without GNSS re-acquisition for some duration. RAN1 can first align understanding that UL transmission can be allowed after original GNSS validity duration expires without GNSS re-acquisition for some duration with legacy closed loop time correction. Companies can first discuss whether GNSS validity duration extension is remaining timeAlignmentTimer or one value configured by network, then whether closed loop time and frequency correction with potential enhancements is needed can be discussed after progress is made for the first one.

## First Round Discussion

***Initial Proposal 1:***

***At least for the case when frequency error is within frequency error requirements, RAN1 can down select one of the following alternatives:***

* ***Alt 1: GNSS validity duration extension is remaining timeAlignmentTimer***
* ***Alt 2: GNSS validity duration extension is one value configured by network***

***Note: GNSS validity duration extension is the duration for UL transmission can be allowed after original GNSS validity duration expires without GNSS re-acquisition with legacy closed loop time correction.***

Companies are encouraged to provide comments within the following table:

|  |  |
| --- | --- |
| Companies | Comments |
| OPPO | This proposal should be discussed after RAN1 agrees that close-loop time domain adjustment can be used to extend the GNSS validity duration. In R17, this is not possible and the UE assumes the UL synchronization is broken and moves to idle phase. In R18, we need an agreement to make this function clear.  |
| Qualcomm | We support to specify an extension to the GNSS validity duration (maybe we can agree to that first, since the previous agreement says “study”?). In our view, the best way to do it would be to introduce a new timer (similar to *timeAlignmentTimer* but separate), since *timeAlignmentTimer* is a timer to control “small drifts”, while the new timer should allow coarser errors (e.g. it is possible the *timeAlignmentTimer* is expired but the UE can still recover through NPRACH). |
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# [Active] Issue #2: GNSS measurement gap

**Agreement (RAN1 111)**

For GNSS measurement in RRC connected, if eNB aperiodically triggers connected UE to make GNSS measurement, UE can re-acquire GNSS position fix with a gap

* FFS details of gap configuration

The UE may re-acquire GNSS autonomously (when configured by the network) if UE does not receive eNB trigger to make GNSS measurement

* FFS based on configured timing

**Agreement (RAN1 112)**

On the length of GNSS measurement gap, which is aperiodically triggered by eNB, the gap duration should be equal to or larger than the latest UE reported GNSS position fix time duration.

FFS: whether the gap duration is configured by eNB, or the gap duration is equal to the latest reported GNSS position fix time duration.

**Agreement (RAN1 112)**

On when the GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, RAN1 can down select one of the following alternatives:

* Alt 1: the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot
* FFS: details of X, e.g. predefined value or configured value
* Alt 2: the start time should be based on the current GNSS validity duration with delay or without delay

## Company contributing views

|  |  |
| --- | --- |
| Contribution | Observation/Proposals |
| Huawei, HiSilicon | Proposal 1: Gap duration for GNSS position fix is configured by eNB and the gap can be longer than the UE reported one. Proposal 2: The GNSS measurement gap starts from the end of n+12 DL subframe where the MAC CE is received ending in DL subframe n. Proposal 3: If the UE decode the MAC CE that triggers GNSS position fix successfully, it can skip the HARQ-ACK feedback if HARQ feedback resource is within the GNSS measurement gap. |
| OPPO | Observation 1: for determining GNSS measurement gap starting location, Alt. 1 is more suitable and efficient.Proposal 1: adopt Alt 1 for GNSS measurement gap start determination and adopt X=12. |
| Spreadtrum | Proposal 1: The start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot. |
| CATT | Proposal 2: Network informs the UE to make the GNSS measurement without explicit gap indidcation.Proposal 3: One minimum measurment gap can be specified based on UE capability. Proposal 4: Start time of GNSS measurement should be based on GNSS validity duration without delay. |
| Nokia, NSB | Observation 1: The common understanding between UE and eNB on when the UE is performing GNSS measurements, and is unavailable for scheduling, is of key importance.Proposal 1: RAN1 to define the GNSS measurement shall be started before the remaining GNSS validity duration expiry.Proposal 2: The eNB shall configure the gap duration for the aperiodically triggered GNSS measurement.Observation 2: the use of HARQ ACK for the message aperiodically triggering the GNSS measurement gap, enables a common understanding between the UE and the eNB about the UE having received the trigger to perform the GNSS measurement.Observation 3: The alternative 1 (“the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot”) enables eNB control of when the GNSS measurement gap starts.Proposal 3: The start time of the aperiodically triggered GNSS measurement gap shall be based on the receiving time of the trigger indication (alternative 1) and guarantee there can be common understanding between UE and network on the gap. |
| Xiaomi | Proposal 3: The length of the measurement gap is equal to the UE’s last reported GNSS position fix time duration.Proposal 4: The start of the measurement gap is indicated in the triggering command. |
| Samsung | Proposal 3: For eNB triggered GNSS measurement, a GNSS measurement window needs to be defined. And, the length of GNSS measurement window can be configured by UE specific RRC signaling. |
| Nordic Semiconductor ASA | Observation 1: The time needed by the UE to get a new location fix may vary a lot from a measurement to another, and thus the configuration of the GNSS measurement gap should be such that the extra delay due to measurement is minimized and, on the other hand, the UE is not unnecessarily dropped off due to failure in acquiring a new position fix in the configured measurement gap. Proposal 2: The start time of the GNSS measurement gap should be n + X, where n is the last subframe where the gap trigger message is received by the UE and X should be configurable by the network.Proposal 4: The GNSS measurement gap is configured with two timers, one specifying a GNSS measurement gap during which the UE is not expected to be scheduled and a GNSS measurement fallback timer giving the UE some extra time to acquire a new position fix. Upon the expiration of the latter timer the UE is expected to either go to RRC-Idle mode or start the RLF procedure. |
| CMCC | Proposal 1. If GNSS measurement gap is applied to enable a new GNSS position fix during long connection times, the common understanding between UE and eNB that UE may automatically perform GNSS operation and NTN NB-IoT/eMTC operation on non-overlapping slot/frame should be achieved.Proposal 2. If the GNSS measurement is triggered aperiodically by eNB, and UE re-acquires GNSS position fix within a GNSS measurement gap, the length of GNSS measurement gap should be equal to or larger than the latest UE reported GNSS position fix time duration, which can be configured by eNB.Proposal 3. If the GNSS measurement is triggered aperiodically by eNB, and UE re-acquires GNSS position fix with a GNSS measurement gap, the start time of GNSS measurement gap can be configured based on the current GNSS validity duration with the following options.* Option 1. The start time of GNSS measurement gap can be configured at the expiration time of the current GNSS validity duration
* Option 2. The start time of GNSS measurement gap can be configured earlier than the expiration of the GNSS validity duration, and GNSS measurement will be completed before the GNSS validity duration expires.
 |
| ZTE | Proposal 1: The duration of GNSS measurement gap should be equal to GNSS position fix time duration reported by UE with consideration of signaling and resource overhead.Proposal 2: The start of GNSS measurement gap should be set to the expiration time of GNSS validity duration without delay to minimize spec effort. |
| MediaTek | Proposal 5: The GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, at $n+k\_{0}^{'}+K\_{offset}+X-1$, where n is the end of MAC CE receiving subframe/slot and X is GNSS measurement gap offset which can be configured by network.Proposal 6: The GNSS measurement gap offset is configured in GNSS measurement trigger MAC CE. |
| Ericsson | Observation 2: Using MAC CE to trigger UEs to acquire GNSS position fix carries a major security risk.Observation 3: Using RRC for reporting the GNSS validity duration and GNSS position fix time duration will trigger SR/BSR when reports are ready while a MAC CE will not trigger SR/BSR. Further RRC is more secure and can reuse the existing gnss-validityDuration IE for the report.Proposal 5: If eNB aperiodically triggers UE to make GNSS measurement, RRC signalling is used.Proposal 6: Network to configure the GNSS measurement gap duration from the following set of values: {1, 2, 5, X} seconds, where X is FFS. |
| Apple | Proposal 2: For aperiodic triggered GNSS measurement, UE performs the GNSS measurement after n+Kmac+3ms, where n is subframe of PUCCH with HARQ corresponding to a PDSCH carrying a MAC CE command on a downlink configuration. |
| Qualcomm | Proposal 3: The gap duration of GNSS measurement triggered by gNB is equal to the latest UE reported GNSS position fix time duration.Proposal 4: On the starting time of the GNSS measurement gap, which is aperiodically triggered by eNB via MAC CE: * Alt 1: the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot.
	+ The value of X depends on whether the PDSCH carrying the MAC-CE has HARQ enabled or disabled.
 |
| Lenovo | Proposal 2: The length of GNSS measurement gap aperiodically triggered can be configured by eNB based on the UE reported capability.Proposal 3: On when the GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, the start time should be Xms after the end of MAC CE reception, and X is predefined as 3ms or 6ms. |

In RAN1 #112, it was agreed that on the length of GNSS measurement gap, which is aperiodically triggered by eNB, the gap duration should be equal to or larger than the latest UE reported GNSS position fix time duration. And RAN1 needs to further discuss whether the gap duration is configured by eNB, or the gap duration is equal to the latest reported GNSS position fix time duration. Besides, on when the GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, two alternatives have been agreed to be considered. Alt 1 considers the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot, while Alt 2 considers the start time should be based on the current GNSS validity duration with delay or without delay.

Contributing companies discussed which alternative should be adopted for the start position and whether network configuration is needed of the gap duration.

1. ***the length of GNSS measurement gap***

Huawei, HiSilicon, Nokia, NSB, Samsung, Nordic Semiconductor ASA, CMCC, Ericsson, Lenovo preferred the gap duration is configured by eNB.

Xiaomi, ZTE, Qualcomm preferred the gap duration is equal to the latest reported GNSS position fix time duration.

* Huawei, HiSilicon mentioned in case of deterioration of channel status or failure of last GNSS position fix, eNB can configure a longer gap than the UE reported one.
* CATT proposed to specify one minimum measurement gap based on UE capability for the UE to make the GNSS measurement without explicit gap indication from network.
* Samsung proposed for eNB triggered GNSS measurement, a GNSS measurement window needs to be defined and the length of GNSS measurement window can be configured by UE specific RRC signaling.
* ZTE mentioned the duration of GNSS measurement gap should be equal to GNSS position fix time duration reported by UE with consideration of signaling and resource overhead.
* Ericsson mentioned network to configure the GNSS measurement gap duration from the following set of values: {1, 2, 5, X} seconds, where X is FFS.
* Lenovo mentioned the length of GNSS measurement gap aperiodically triggered can be configured by eNB based on the UE reported capability.
1. ***start position of*** ***GNSS measurement gap***

Huawei, HiSilicon, OPPO, Spreadtrum, Nokia, NSB, Nordic Semiconductor ASA, MediaTek, Apple, Qualcomm, Lenovo preferred Alt 1: the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot.

CMCC, ZTE preferred Alt 2: the start time should be based on the current GNSS validity duration with delay or without delay.

* Huawei, HiSilicon mentioned Alt1 is more flexible than Alt2. Huawei, HiSilicon further proposed if the UE decode the MAC CE that triggers GNSS position fix successfully, it can skip the HARQ-ACK feedback if HARQ feedback resource is within the GNSS measurement gap as Figure 2 from R1-2302367.



**Figure 1.** Application timing of of MAC CE that triggers GNSS position fix when MAC CE is successfully decoded

* OPPO proposed to adopt Alt 1 for GNSS measurement gap start determination and adopt X=12, consider Alt. 1 is more suitable and efficient.
* Nokia, NSB mentioned Alt 1 can guarantee there can be common understanding between UE and network on the gap and RAN1 to define the GNSS measurement shall be started before the remaining GNSS validity duration expiry. Nokia, NSB further observed the use of HARQ ACK for the message aperiodically triggering the GNSS measurement gap, enables a common understanding between the UE and the eNB about the UE having received the trigger to perform the GNSS measurement and the alternative 1 enables eNB control of when the GNSS measurement gap starts.
* Xiaomi proposed the start of the measurement gap is indicated in the triggering command.
* Nordic Semiconductor ASA mentioned the start time of the GNSS measurement gap should be n + X, where n is the last subframe where the gap trigger message is received by the UE and X should be configurable by the network.
* CMCC proposed the start time of GNSS measurement gap can be configured based on the current GNSS validity duration with the following options, Option 1. The start time of GNSS measurement gap can be configured at the expiration time of the current GNSS validity duration, Option 2. The start time of GNSS measurement gap can be configured earlier than the expiration of the GNSS validity duration, and GNSS measurement will be completed before the GNSS validity duration expires.
* ZTE mentioned the start of GNSS measurement gap should be set to the expiration time of GNSS validity duration without delay to minimize spec effort as shown in Figure 1 of R1-2303297.



Figure 1 An illustration of GNSS update in RRC connection

* MediaTek mentioned the GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, at $n+k\_{0}^{'}+K\_{offset}+X-1$, where n is the end of MAC CE receiving subframe/slot and X is GNSS measurement gap offset which can be configured by network and the GNSS measurement gap offset is configured in GNSS measurement trigger MAC CE.
* Apple mentioned for aperiodic triggered GNSS measurement, UE performs the GNSS measurement after n+Kmac+3ms, where n is subframe of PUCCH with HARQ corresponding to a PDSCH carrying a MAC CE command on a downlink configuration.
* Qualcomm mentioned on the starting time of the GNSS measurement gap, which is aperiodically triggered by eNB via MAC CE with Alt 1: the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot and the value of X depends on whether the PDSCH carrying the MAC-CE has HARQ enabled or disabled.
* Lenovo mentioned on when the GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, the start time should be Xms after the end of MAC CE reception, and X is predefined as 3ms or 6ms
1. ***others***
* Nordic Semiconductor ASA observed that the time needed by the UE to get a new position fix may vary a lot from a measurement to another, and thus the configuration of the GNSS measurement gap should be such that the extra delay due to measurement is minimized and, on the other hand, the UE is not unnecessarily dropped off due to failure in acquiring a new position fix in the configured measurement gap. Nordic Semiconductor ASA further proposed the GNSS measurement gap is configured with two timers, one specifying a GNSS measurement gap during which the UE is not expected to be scheduled and a GNSS measurement fallback timer giving the UE some extra time to acquire a new position fix as shown in Fig. 1 of R1-2303176. To the moderator understanding, if there is some delay needed, network can configure a larger gap duration than the latest UE reported GNSS position fix time duration for measurement.



**Figure 1: Configuration of GNSS measurement gap with associated timers**

* Ericsson mentioned using MAC CE to trigger UEs to acquire GNSS position fix carries a major security risk and using RRC for reporting the GNSS validity duration and GNSS position fix time duration will trigger SR/BSR when reports are ready while a MAC CE will not trigger SR/BSR. Further RRC is more secure and can reuse the existing gnss-validityDuration IE for the report. Ericsson further proposed if eNB aperiodically triggers UE to make GNSS measurement, RRC signalling is used. To the moderator understanding, RAN1 has agreed to utilize MAC CE to aperiodically trigger GNSS measurement gap, and whether to add RRC signalling can be discussed in RAN2, while some companies in RAN2 still have concerns on the security of RRC in CP mode and the signaling using MAC CE is not transferring the user data with very limited damage (similar to the existing MAC CE like Timing Advance Command).

Moderator View: On the length of GNSS measurement gap, some contributing companies mentioned the GNSS measurement gap can be configured by eNB, considering channel status and other information. To the moderator understanding, the duration for the GNSS measurement gap can be configured by eNB, and when the duration for GNSS measurement gap is not configured by eNB, the gap duration is equal to the latest reported GNSS position fix time duration for measurement. On when the GNSS measurement gap starts, RAN1 can do the down select first, then details can be discussed later.

## First Round Discussion

***Initial Proposal 2-1:***

***For the GNSS measurement gap aperiodically triggered with MAC CE, the duration for the GNSS measurement gap can be configured by eNB.***

***Note: The gap duration is equal to the latest reported GNSS position fix time duration for measurement when the duration for GNSS measurement gap is not configured by eNB.***

***Initial Proposal 2-2:***

***Companies are encouraged to down select one of the following alternatives on when the aperiodic GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, and provide comments:***

* ***Alt 1: the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot***

***o FFS: details of X, e.g. predefined value or configured value***

* ***Alt 2: the start time should be based on the current GNSS validity duration with delay or without delay***

Companies are encouraged to provide comments in the table.

|  |  |
| --- | --- |
| Companies | Comments |
| OPPO | Proposal 2-1: fineProposal 2-2: it is the same as previous RAN1 agreement. Hence this proposal is not needed. If FL asks company views to down-select, we prefer Alt-1.  |
| Qualcomm | Proposal 2-1: We think the cases in which the gap can be longer than the UE reported one are really corner cases, and therefore we would like to keep the UE reported gap.Proposal 2-2: There is a clear majority for Alt-1, can we go with that? We also brought up the issue that the value of X may depend on whether the UE is providing HARQ-ACK feedback for the MAC-CE. |
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# [Active] Issue #3: autonomously GNSS measurement based on configured timing

**Agreement (RAN1 111)**

For GNSS measurement in RRC connected, if eNB aperiodically triggers connected UE to make GNSS measurement, UE can re-acquire GNSS position fix with a gap

* FFS details of gap configuration

The UE may re-acquire GNSS autonomously (when configured by the network) if UE does not receive eNB trigger to make GNSS measurement

* FFS based on configured timing

## Company contributing views

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| --- | --- |
| Contribution | Observation/Proposals |
| Huawei, HiSilicon | Proposal 8: UE can initiate a timer for autonomous GNSS measurement when GNSS validity duration and TAT (if supported) expires, and UE is not performing GNSS measurement triggered by eNB. UE enters idle mode if UE cannot reacquire GNSS before the timer expires. |
| OPPO | Proposal 4: UE shall autonomously performs GNSS acquisition if the UE does not receive GNSS re-acquisition triggering until the end of the GNSS validity duration. |
| CATT | Proposal 6: UE shouldn’t perform GNSS measurement autonomously if gNB has not sent the GNSS triggering indication, in which case gNB will assume UE will enter RRC-IDLE mode. |
| NEC | Proposal 4: The UE may re-acquire GNSS autonomously based on configured timing if it does not receive eNB trigger to make GNSS measurement. |
| Nokia, NSB | Observation 4: UE and eNB must have a common understanding of when and for how long the UE is performing the autonomous GNSS measurement.Proposal 4: For UE autonomous GNSS measurements, the alternative 2 (“the start time should be based on the current GNSS validity duration with delay or without delay”) can be discussed as per eNB configuration of the measurement start time relative to and before the GNSS validity duration expiry. |
| ZTE | Proposal 5: For configuration of GNSS measurement timer in connected, the complexity and spec impact should also be minimized. * The GNSS measurement timer starts at the expiration time of GNSS validity duration.
* The GNSS measurement timer length is equal to GNSS position fix time duration reported by UE at initial access stage.
 |
| MediaTek | Observation 1: Timer(s) [Timer T1 and Timer T2] can be configured for UE to re-acquire GNSS measurement autonomously. Proposal 3: From RAN1 perspective, configured timing for UE re-acquires GNSS autonomously are timer(s). The configuration of GNSS measurement Timer is up to RAN2.Proposal 4: UE re-acquires GNSS measurement autonomously can start at the point when GNSS validity duration expires and timeAlignmentTimer expires. |
| InterDigital | Observation 2: NB-IoT UEs with CP solution only do not support RRC reconfiguration. If UE is configured via RRC with timing to autonomously re-acquire GNSS, the timing cannot be reconfigured to accommodate changes in e.g., validity duration.Proposal 4: A UE may re-acquire GNSS autonomously (when configured by the network) based on configured timing for at least eMTC UEs. FFS for NB-IoT UEs. |
| Qualcomm | Proposal 7: The start time of a UE-autonomous GNSS measurement gap is defined with respect to the end of the GNSS validity duration.• FFS: details. |

In RAN1 #111, it was agreed that the UE may re-acquire GNSS autonomously (when configured by the network) if UE does not receive eNB trigger to make GNSS measurement. The timing of autonomous measurement is FFS

Contributing companies mentioned the start position and configuration of the timing of autonomous GNSS measurement.

1. ***configuration of the timing duration (timer) and others for autonomous GNSS measurement***
* CATT mentioned UE shouldn’t perform GNSS measurement autonomously if gNB has not sent the GNSS triggering indication, in which case gNB will assume UE will enter RRC-IDLE mode. To the moderator understanding, the motivation of agreed autonomous GNSS measurement is to let UE have a last chance to perform GNSS measurement before going to IDLE considering that Rel-18 mainly consider the scenario for long connection time. Besides, if there does have a need not to let UE re-acquire GNSS measurement in RRC connected with autonomous GNSS measurement timer, network can configure the timer length equals to zero.
* ZTE mentioned the GNSS measurement timer length is equal to GNSS position fix time duration reported by UE at initial access stage.
* MediaTek proposed from RAN1 perspective, configured timing for UE re-acquires GNSS autonomously are timer(s) and the configuration of GNSS measurement Timer is up to RAN2.
* InterDigital mentioned NB-IoT UEs with CP solution only do not support RRC reconfiguration. If UE is configured via RRC with timing to autonomously re-acquire GNSS, the timing cannot be reconfigured to accommodate changes in e.g., validity duration and proposed a UE may re-acquire GNSS autonomously (when configured by the network) based on configured timing for at least eMTC UEs. FFS for NB-IoT UEs. To the moderator understanding, the timing to autonomously re-acquire GNSS can start at expiry of GNSS validity duration with delay or without delay, then configured timing mechanism can be supported both eMTC and NB-IoT.
1. ***start position of the timing of autonomous GNSS measurement***
* Huawei, HiSilicon proposed UE can initiate a timer for autonomous GNSS measurement when GNSS validity duration and TAT (if supported) expires, and UE is not performing GNSS measurement triggered by eNB.
* OPPO mentioned UE shall autonomously performs GNSS acquisition if the UE does not receive GNSS re-acquisition triggering until the end of the GNSS validity duration as shown in Fig. 2 of R1-2302567.



Fig. 2: UE autonomous GNSS re-acquisition procedure

* Nokia, NSB proposed for UE autonomous GNSS measurements, the start time should be based on the current GNSS validity duration with delay or without delay can be discussed as per eNB configuration of the measurement start time relative to and before the GNSS validity duration expiry. And UE and eNB must have a common understanding of when and for how long the UE is performing the autonomous GNSS measurement.
* ZTE mentioned the GNSS measurement timer starts at the expiration time of GNSS validity duration.
* MediaTek proposed UE re-acquires GNSS measurement autonomously can start at the point when GNSS validity duration expires and timeAlignmentTimer expires as illustrated in Figure 1 from R1-2303358.



***Figure 1****: UE autonomously re-acquiring GNSS measurement mechanism*

* Qualcomm mentioned the start time of a UE-autonomous GNSS measurement gap is defined with respect to the end of the GNSS validity duration.

Moderator View: The detailed configuration and starting position of autonomously GNSS measurement based on configured timing are mentioned by contributing companies. For autonomously GNSS measurement based on configured timing mechanism, majority contributing companies discussed with timer(s). Similar to the length of GNSS measurement gap, the autonomously GNSS measurement timer can be configured with values equal to or larger than the latest UE reported GNSS position fix time duration. Besides, the start time of the autonomous GNSS measurement timer should be based on the current GNSS validity duration with delay or without delay.

## First Round Discussion

***Initial Proposal 3-1:***

***The length of GNSS measurement timer can be configured with values equal to or larger than the latest UE reported GNSS position fix time duration.***

* ***FFS: candidate values for the length of GNSS measurement timer***

***Note: The UE may re-acquire GNSS autonomously if UE does not receive eNB trigger to make GNSS measurement during GNSS measurement timer, where GNSS measurement timer is configured by network.***

***Initial Proposal 3-2:***

***The start time of the autonomous GNSS measurement timer should be based on the current GNSS validity duration with delay or without delay.***

Companies are encouraged to provide comments in the table.

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| --- | --- |
| Companies | Comments |
| OPPO | For proposal 3-1, the introduction of GNSS measurement timer is intended for a duration in which UE performs GNSS re-acquisition (similar to GNSS measurement gap)? or is it intended for a delay after GNSS validity duration but before the UE performs autonomous GNSS re-acquisition? If it is the latter, it may be too early to discuss this proposal. We can first agree on the GNSS validity duration extension. Also, there is another proposed alternative to following TAT timer. For proposal 3-2, we are fine.  |
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# [Active] Issue #4: GNSS assistance information

The moderator recalls the agreements for GNSS assistance information.

**Agreement (RAN1 107-e):**

The UE autonomously determines its GNSS validity duration X and reports information associated with this valid duration to the network via RRC signalling.

* X = {10s, 20s, 30s, 40s, 50s, 60s, 5 min, 10 min, 15 min, 20 min, 25 min, 30 min, 60 min, 90 min, 120 min, infinity}

Send LS to RAN2 to take the following RAN1 agreements into consideration to specify the aspects related to GNSS position validity:

* For sporadic short transmission, UE in RRC\_CONNECTED should go back to idle mode and re-acquire a GNSS position fix if GNSS becomes outdated
* The UE autonomously determines its GNSS validity duration X and reports information associated with this valid duration to the network via RRC signalling.
	+ X = {10s, 20s, 30s, 40s, 50s, 60s, 5 min, 10 min, 15 min, 20 min, 25 min, 30 min, 60 min, 90 min, 120 min, infinity}
* Note: The duration of the short transmission is not longer than the “validity timer for UL synchronization” referred to in the WID objective (but which still needs further discussion for specifying further details)

**Agreement (RAN1 109-e):**

UE reports additional GNSS assistance information and further study the detailed GNSS assistance information, including e.g. GNSS position fix measurement time

* Note: Since RAN1 agreed that GNSS validity duration is reported by UE in Rel-17, it is already included in GNSS assistance information.

**Agreement (RAN1 110):**

GNSS assistance information that UE reports to eNB at least consists of:

* GNSS position fix time duration for measurement
* GNSS validity duration

**Agreement (RAN1 110bis-e):**

UE reports GNSS position fix time duration for measurement at least during the initial access stage

* which message carries this information is up to RAN2

**Agreement (RAN1 110bis-e):**

In connected mode, UE may report GNSS validation duration with MAC CE.

**Agreement (RAN1 112):**

UE reports only one GNSS position fix time duration for GNSS measurement at least when moving to RRC connected state.

**RAN2-118**

* A new parameter for remaining GNSS validity duration is introduced in Msg5, e*.g. RRCConnectionResumeComplete*, *RRCConnectionSetupComplete* and RRCreestablishmentComplete messages, and the parameter refers to the time of message transmission.
* P1: The value range of the remaining GNSS validity duration should include the values proposed by RAN1 , i.e. {10s, 20s, 30s, 40s, 50s, 60s, 5 min, 10 min, 15 min, 20 min, 25 min, 30 min, 60 min, 90 min, 120 min, infinity}.
* P3: The new parameter for remaining GNSS validity duration is introduced in the following Msg5 messages: RRCConnectionResumeComplete, RRCConnectionSetupComplete, RRCreestablishmentComplete RRCConnectionResumeComplete-NB, RRCConnectionSetupComplete-NB, RRCreestablishmentComplete-NB.
* P4: The new parameter for remaining GNSS validity duration is introduced in *RRCConnectionReconfigurationComplete* for MTC Handover.
* P5: No new RRC release cause “GNSS invalidity” is introduced in RRC Release.
* This mechanism is not configurable, and the UE always reports.

**RAN2-121**

* For UE to report GNSS position fix time duration for measurement during the initial access, at least the following Msg5 message can be used:

 o RRCConnectionSetupComplete, RRCConnectionSetupComplete-NB,

 o RRCConnectionResumeComplete, RRCConnectionResumeComplete-NB,

 o FFS for RRCreestablishmentComplete and RRCConnectionReconfigurationComplete.

 o FFS for Msg3

* FFS whether the UE can stay in RRC\_CONNECTED state when current GNSS position becoming out-of-date if the UE has initiated a new measurement
* The value range {10s, 20s, 30s, 40s, 50s, 60s, 5 min, 10 min, 15 min, 20 min, 25 min, 30 min, 60 min, 90 min, 120 min, infinity} introduced in R17 is reused for connected UE GNSS validation duration report, unless modified by RAN1.
* UE reports GNSS validity duration after GNSS measurement. FFS whether the UE reports every time or only if the validity duration changes. FFS if the duration is the remaining validity duration or the whole duration

## Company contribution views

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| --- | --- |
| Contribution | Observation/Proposals |
| Huawei, HiSilicon | Proposal 4: The first NPUSCH scheduled by eNB after measurement gap can be used by UE to indicate the success of GNSS position fix. UE can update the validity duration in the MAC CE of the NPUSCH If GNSS validity duration is changed since the last measurement.Proposal 5: The fresh GNSS validity duration is restarted from the end of the GNSS measurement gap. |
| Nokia, NSB | Observation 10: The UE may move and/or the propagation conditions may change and therefore cause a change in the required GNSS position fix time duration.Proposal 10: RAN1 to discuss UE reporting GNSS position fix time duration if the duration has changed since the previous report.Observation 11: The UE’s mobility state/location may change and therefore cause a change in the expected GNSS validity duration.Observation 12: GNSS reacquisition may not always be needed if the UE has been RRC Idle for a short period during a long connection.Proposal 11: RAN1 to discuss how UE can trigger the reporting of GNSS validity duration if the duration has changed and after a short period in RRC Idle. |
| CMCC | Proposal 5. In connected mode, if the GNSS measurement is aperiodically triggered by eNB, UE will report the updated GNSS validity duration after completing GNSS measurement only when the GNSS validity duration changes. |
| MediaTek | Proposal 2: UE reports one GNSS position fix time duration value using a 3-bit field with [1,2,3,7,13,19,25,37] seconds when moving to RRC connected state. |
| Ericsson | Proposal 8: A UE in connected mode shall always report its GNSS validity duration after GNSS reacquisition.Proposal 10: UE to report its GNSS measurement time duration in connected mode using a 2-bit field from the following set of values: {1, 2, 5, X} seconds, where X is FFS.Proposal 11: UE reports only one value (from the set of possible values) for the GNSS measurement time duration in RRC connected state. |
| InterDigital | Proposal 1: Introduce a new ‘GNSS acquisition assistance information MAC CE’ to report GNSS validity duration in connected mode.Observation 1: Both validity duration and position fix time duration can vary dynamically based on UE characteristics (e.g. surroundings, UE speed).Proposal 2: In connected mode, UE may also optionally report GNSS position fix time duration via the new GNSS acquisition assistance information MAC CE (e.g. if the current value has changed since the previous report during initial access).Proposal 3: In connected mode, GNSS assistance information MAC CE is at least sent upon NW request. FFS other reporting trigger conditions. |
| Qualcomm | Proposal 2: After a GNSS reacquisition, the UE reports its new GNSS validity duration to the eNB:* The validity duration indicates the “remaining validity duration”.
* The reporting is performed regardless of the method of GNSS reacquisition (UE autonomous, eNB triggered, etc.)
 |
| Lenovo | Proposal 7: UE is not expected to further update the GNSS position fix time duration in connected. |

It has been agreed for GNSS assistance information that UE reports to eNB at least consists of: GNSS position fix time duration for measurement and GNSS validity duration; UE reports only one GNSS position fix time duration for GNSS measurement at least when moving to RRC connected state (RAN2 has agreed that GNSS position fix time duration for measurement is reported in Msg5 message); in connected mode, UE may report GNSS validation duration with MAC CE and RAN2 has agreed on the value range {10s, 20s, 30s, 40s, 50s, 60s, 5 min, 10 min, 15 min, 20 min, 25 min, 30 min, 60 min, 90 min, 120 min, infinity}.

1. ***On GNSS position fix time duration***

In RAN2-121, it has been agreed that for UE to report GNSS position fix time duration for measurement during the initial access, at least the following Msg5 message can be used:

 o RRCConnectionSetupComplete, RRCConnectionSetupComplete-NB,

 o RRCConnectionResumeComplete, RRCConnectionResumeComplete-NB,

 o FFS for RRCreestablishmentComplete and RRCConnectionReconfigurationComplete.

 o FFS for Msg3

* Nokia, NSB mentioned RAN1 to discuss UE reporting GNSS position fix time duration if the duration has changed since the initial access stage report.
* MediaTek mentioned from GPS ICD, the whole message contains 25 pages (or ’frames’) of 30 seconds each, forming the master frame that takes 12,5 minutes to be transmitted. Every frame is subdivided into 5 sub-frames of 6 seconds each. Every sub-frame always starts with the telemetry word (TLM), which is necessary for synchronism. The typical value for warm start should be times of 6 seconds where each sub-frame with 6 seconds is necessary for synchronism. MediaTek further proposed UE reports one GNSS position fix time duration value using a 3-bit field with [1,2,3,7,13,19,25,37] seconds when moving to RRC connected state considering possible processing time for UE to re-acquire GNSS position fix and DL synchronization after GNSS measurement within GNSS measurement gap/timer.



Figure 1: "Legacy" Navigation message from GPS ICD

* Ericsson proposed UE to report only one value (from the set of possible values) for its GNSS measurement time duration in connected mode using a 2-bit field from the following set of values: {1, 2, 5, X} seconds, where X is FFS.
* InterDigital mentioned to introduce a new ‘GNSS acquisition assistance information MAC CE’ to report GNSS validity duration in connected mode and in connected mode, UE may also optionally report GNSS position fix time duration via the new GNSS acquisition assistance information MAC CE (e.g. if the current value has changed since the previous report during initial access), where GNSS assistance information MAC CE is at least sent upon NW request. FFS other reporting trigger conditions.
* Lenovo mentioned UE is not expected to further update the GNSS position fix time duration in connected.
1. ***On GNSS validity duration in RRC connected***

In RAN2-121, it has been agreed that The value range {10s, 20s, 30s, 40s, 50s, 60s, 5 min, 10 min, 15 min, 20 min, 25 min, 30 min, 60 min, 90 min, 120 min, infinity} introduced in R17 is reused for connected UE GNSS validation duration report, unless modified by RAN1 and UE reports GNSS validity duration after GNSS measurement with FFS whether the UE reports every time or only if the validity duration changes and FFS if the duration is the remaining validity duration or the whole duration.

* Huawei, HiSilicon mentioned UE can update the validity duration in the MAC CE of the NPUSCH if GNSS validity duration is changed since the last measurement and the fresh GNSS validity duration is restarted from the end of the GNSS measurement gap.
* Nokia, NSB observed the UE’s mobility state/location may change and therefore cause a change in the expected GNSS validity duration and GNSS reacquisition may not always be needed if the UE has been RRC Idle for a short period during a long connection. Nokia, NSB proposed RAN1 to discuss how UE can trigger the reporting of GNSS validity duration if the duration has changed and after a short period in RRC Idle. To the moderator understanding, in Rel-17, RAN2 has agreed he value range of the remaining GNSS validity duration should include the values proposed by RAN1, i.e. {10s, 20s, 30s, 40s, 50s, 60s, 5 min, 10 min, 15 min, 20 min, 25 min, 30 min, 60 min, 90 min, 120 min, infinity}.
* CMCC proposed in connected mode, if the GNSS measurement is aperiodically triggered by eNB, UE will report the updated GNSS validity duration after completing GNSS measurement only when the GNSS validity duration changes.
* Ericsson mentioned A UE in connected mode shall always report its GNSS validity duration after GNSS reacquisition.
* InterDigital proposed a new ‘GNSS acquisition assistance information MAC CE’ to report GNSS validity duration in connected mode and GNSS assistance information MAC CE is at least sent upon NW request. FFS other reporting trigger conditions. InterDigital also mentioned in connected mode, UE may also optionally report GNSS position fix time duration via the new GNSS acquisition assistance information MAC CE (e.g. if the current value has changed since the previous report during initial access).
* Qualcomm mentioned after a GNSS reacquisition, the UE reports its new GNSS validity duration to the eNB, and the reporting is performed regardless of the method of GNSS reacquisition (UE autonomous, eNB triggered, etc.). Qualcomm further mentioned the validity duration indicates the “remaining validity duration”.

Moderator View: On GNSS position fix time duration, in RAN2-121, it has been agreed that for UE to report GNSS position fix time duration for measurement during the initial access, at least the following Msg5 message can be used: RRCConnectionSetupComplete, RRCConnectionSetupComplete-NB, RRCConnectionResumeComplete, RRCConnectionResumeComplete-NB. It seems reasonable where UE to report its GNSS measurement time duration using a 3-bit field from the following set of values: {1,2,3,7,13,19,25, X} seconds, where X is FFS. On GNSS validity duration, RAN2 has agreed on the value range {10s, 20s, 30s, 40s, 50s, 60s, 5 min, 10 min, 15 min, 20 min, 25 min, 30 min, 60 min, 90 min, 120 min, infinity} introduced in R17 is reused. On when/how UE should report the GNSS assistance information can be further discussed.

## First Round Discussion

***Initial Proposal 4-1:***

***UE reports one GNSS position fix time duration for GNSS measurement via a N-bit field, when moving to RRC connected state***

* ***FFS: N=3, with value in [1,2,3,7,13,19,25, X] seconds, and X is FFS.***

***Initial Proposal 4-2:***

***Companies are encouraged to comment on:***

* ***Whether UE needs to*** ***report GNSS position fix time duration for GNSS measurement in RRC connected state.***
* ***Whether the UE reports*** ***GNSS validity duration after GNSS measurement every time or only if the validity duration changes in RRC connected.***

Companies are encouraged to provide comments within the following table:

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| --- | --- |
| Companies | Comments |
| OPPO | When the expected GNSS measurement duration is significantly changed, it is necessary to inform the network about this change. Regarding whether the UE needs to inform the network every time, it is up to the discussion outcome on the topic whether the network needs to know the success of the GNSS re-acquisition. In last meeting we agreed that explicit information such as updated GNSS validity duration can be used to derive the success of GNSS re-acquisition. Thus, we think that proposal 4-2 is relevant also to whether the success of GNSS re-acquisition has to be informed to the network and how.  |
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# [Active] Issue #5: GNSS measurement and C-DRX

## 5.1 Company contributing views

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| Contribution | Observation/Proposals |
| Huawei, HiSilicon | Proposal 9: UE may re-acquire GNSS autonomously during the inactive state of UE’s C-DRX when DL/UL idle period is longer than the GNSS measurement duration. UE could report the successful GNSS position fix when re-enter active state, with validity duration update, if applicable based on the measurement not triggered by network. |
| Nokia, NSB | Observation 15: Inactive state of C-DRX may not occur at all or be shorter than expected due to extension of the active state because of new data and retransmissions.Observation 16: RRM measurement gaps may occur during the inactive state of Connected DRX and therefore prohibit the GNSS measurement.Observation 17: UE may need to reacquire SIB31 during the inactive state of Connected DRX and is therefore not able to perform the GNSS measurement.And the following proposals:Proposal 14: RAN1 to postpone the discussion on whether the UE can reacquire the GNSS position fix outside the Connected DRX Active Time. |
| CMCC | Proposal 8. UE can autonomously re-acquire GNSS position fix during inactive state of C-DRX when the inactive state of C-DRX is longer than the GNSS fix time duration for measurement. |
| ZTE | Proposal 9: UE should be supported to re-acquire GNSS during inactive state of C-DRX. The time for GNSS re-acquisition during inactive state of C-DRX should be specified as a time interval right before switch to active time to maximize the usage of GNSS validity duration. |
| MediaTek | Proposal 7: UE can re-acquire GNSS position fix autonomously during inactive state of Connected DRX. |
| Ericsson | Proposal 7: The discussion on supporting UE-triggered GNSS measurements during the sleep mode of C-DRX should be left to RAN2. |
| InterDigital | Proposal 5: A UE may re-acquire GNSS autonomously during the inactive state of C-DRX if the inactive state is longer than the GNSS fix time duration. |

The GNSS measurement and C-DRX issue was discussed in past few meetings without consensus. Contributing companies’ comments are summarized in following table.

Table 2 the comments on support UE autonomously perform GNSS measurement during the inactive state of C-DRX

|  |  |  |  |
| --- | --- | --- | --- |
| Contribution | Support | Not support | Comments |
| Huawei, HiSilicon | √ |  | UE may re-acquire GNSS autonomously during the inactive state of UE’s C-DRX when DL/UL idle period is longer than the GNSS measurement duration. UE could report the successful GNSS position fix when re-enter active state, with validity duration update, if applicable based on the measurement not triggered by network. |
| Nokia, NSB |  | postpone | Inactive state of C-DRX may not occur at all or be shorter than expected due to extension of the active state because of new data and retransmissions. RRM measurement gaps may occur during the inactive state of Connected DRX and therefore prohibit the GNSS measurement. UE may need to reacquire SIB31 during the inactive state of Connected DRX and is therefore not able to perform the GNSS measurement. |
| CMCC | √ |  | UE can autonomously re-acquire GNSS position fix during inactive state of C-DRX when the inactive state of C-DRX is longer than the GNSS fix time duration for measurement. |
| ZTE | √ |  | In inactive state of C-DRX, UE will not detect PDCCH and thus does not receive signaling. UE should be supported to re-acquire GNSS during inactive state of C-DRX. The time for GNSS re-acquisition during inactive state of C-DRX should be specified as a time interval right before switch to active time to maximize the usage of GNSS validity duration. |
| MediaTek | √ |  | It has been agreed in Rel-17 that UE may need to re-acquire the GNSS fix right before establishing the connection (regardless if previously valid or not), if needed to avoid interruption during the connection and similar way can be reused for Rel-18 inactive state of C-DRX. UE can re-acquire GNSS position fix autonomously during inactive state of Connected DRX. |
| Ericsson |  |  | The discussion on supporting UE-triggered GNSS measurements during the inactive mode of C-DRX should be left to RAN2. |
| InterDigital | √ |  | Since a UE is not required to monitor PDCCH during inactive state of C-DRX, it seems straightforward to allow a UE to re-acquire GNSS autonomously during the inactive state if the inactive state is longer than the GNSS fix time duration and the UE doesn’t need to perform any measurement (e.g., RLM, RRM) which can be handled by UE implementation though. |

Moderator View: Majority contributing companies support that UE can re-acquire GNSS position fix during inactive state of Connected DRX. As specified in TS 36.321, when a DRX cycle is configured, the Active Time includes the time while *onDurationTimer* or *drx-InactivityTimer* or *drx-RetransmissionTimer* or *drx-RetransmissionTimerShortTTI* or *drx-ULRetransmissionTimer* or *drx-ULRetransmissionTimerShortTTI* or *mac-ContentionResolutionTimer* is running. And As mentioned by some contributed companies, during the inactive/idle/sleep state, where UE is not required to transmit and receiving, it is beneficial for UE to re-acquire GNSS position fix to avoid interruption during the connection when the configuration of the inactive mode of C-DRX is possible for UE to do GNSS measurement. And RAN1 can discuss it from RAN1 perspective, then RAN1 can leave it to RAN2 to discuss standard impact or details considering RAN1 consensus.

## 5.2 First Round Discussion

***Initial Proposal 5:***

***From RAN1 perspective, UE can autonomously re-acquire GNSS position fix during inactive state of Connected DRX.***

***FFS: details are up to RAN2***

Companies are encouraged to provide comments within the following table:

|  |  |
| --- | --- |
| Companies | Comments |
| Qualcomm | In general, we support that the UE can perform GNSS measurements (up to implementation, no requirement). The procedure should be the same as with gaps: if the GNSS validity duration changed, then the UE should report the new validity duration. |
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# [Active] Issue #6: success/failure of GNSS measurement

**RAN2-116bis**

UE need to have a valid GNSS fix before going to connected. RAN2 assumes that the UE may need to re-acquire the GNSS fix right before establishing the connection (regardless if previously valid or not), if needed to avoid interruption during the connection.

When the GNSS fix becomes outdated in RRC\_CONNECTED mode, the UE goes to IDLE mode.

**Agreement (RAN1 112):**

The following alternatives can be considered to inform eNB the success of GNSS measurement at UE side after GNSS measurement in RRC connected.

* Alt-1: The UE will report the new GNSS validity duration
* Alt-2: The reception of any UL transmission from the UE at eNB after the GNSS measurement

## 6.1 Company contributing views

|  |  |
| --- | --- |
| Contribution | Observation/Proposals |
| Huawei, HiSilicon | Proposal 4: The first NPUSCH scheduled by eNB after measurement gap can be used by UE to indicate the success of GNSS position fix. UE can update the validity duration in the MAC CE of the NPUSCH If GNSS validity duration is changed since the last measurement.Proposal 6: UE should stop UL transmission after measurement gap if GNSS position fix fails in the gap unless GNSS is re-acquired by other supported mechanism, e.g. autonomous GNSS measurement.Proposal 8: UE can initiate a timer for autonomous GNSS measurement when GNSS validity duration and TAT (if supported) expires, and UE is not performing GNSS measurement triggered by eNB. UE enters idle mode if UE cannot reacquire GNSS before the timer expires. Proposal 9: UE may re-acquire GNSS autonomously during the inactive state of UE’s C-DRX when DL/UL idle period is longer than the GNSS measurement duration. UE could report the successful GNSS position fix when re-enter active state, with validity duration update, if applicable based on the measurement not triggered by network. |
| OPPO | Observation 2: The network may not know exactly when the UE finishes the GNSS re-acquisition and if the network intends to do a blind scheduling, not only will it cause spectrum waste, but also it results in the power consumption waste for both UE and eNB power consumption. Observation 3: The GNSS measurement gap has often long duration, the configured SPS may cause a waste of spectrum efficiency.Proposal 2: After the UE GNSS re-acquisition the UE will start to monitor NPDCCH only after the UE sends the SR.Proposal 6: UE needs to perform RACH procedure after accomplishing the GNSS measurement to inform the eNB that the measurement is accomplished.Proposal 3: UE expects the GNSS re-acquisition triggering from eNB within the GNSS validity duration.Proposal 5: UE goes to idle if the GNSS acquisition fails within the measurement gap.  |
| CATT | Observation 1: UE is not necessary to report the new GNSS validity duration if it is same as old GNSS validity duration. Proposal 5: UE should send UL PRACH signal to indicate network when the GNSS measurement is successful. |
| Nokia, NSB | Observation 13: Alternative 1 (UE reporting the new GNSS validity duration after successful GNSS measurement) is preferred, because it enables a common understanding between UE and eNB.Proposal 12: The UE shall indicate success of the GNSS measurement by an explicit indication.Proposal 13: RAN1 to discuss whether the UE can provide an explicit indication of successful GNSS measurement and optionally include the new GNSS validity duration, when the duration is different from the previous duration.Observation 14: Alternative 2 (UE indicating successful GNSS measurement by any uplink transmission) is not preferred, because it may cause network to attempt downlink transmission to a UE, which is no longer RRC connected. |
| Xiaomi | Proposal 5: UE reports the new GNSS validity duration after the successful GNSS measurement. |
| Nordic Semiconductor ASA | Proposal 3: After the GNSS measurement gap, the network may request UE to transmit a new GNSS validity duration value or a contention free (N)PRACH via (N)PDCCH order. Either one of those will implicitly inform the network that the GNSS measurement was successful. |
| CMCC | Proposal 6. To inform eNB the success of acquiring GNSS position fix, the indication of success after GNSS measurement can be considered if implicit indication is not sufficient.Proposal 7. If UE can not re-acquire the new GNSS position fix successfully until the GNSS validity duration expires, the UE goes to IDLE mode. |
| ZTE | Proposal 6: The reception of any UL transmission after GNSSS measurement is preferred to indicate success/completion of GNSS position fix without additional signaling overhead and scheduling delay.Proposal 7: The success indication of GNSS position fix should be transmitted within a time window after GNSS measurement. The GNSS position fix is thought failed if no success indication within the time window.* The time window starts at the end of GNSS measurement gap or timer/timing.
* The time window length is configured by network.
 |
| MediaTek | Observation 2: After UE re-acquires GNSS position fix in RRC connected, UE has a valid GNSS, for the first UL transmission: * the first UL data transmission: UE needs a RACH with SR before transmitting data, this can implicitly indicate success of GNSS measurement.
* the first NPDCCH ordered NPRACH transmission: UE sends a NPDCCH ordered NPRACH, this can implicitly indicate success of GNSS measurement.
* the first UL HARQ ACK/NACK transmission: If UE receives DL packet and sends HARQ ACK/NACK for the packet after applying the timing advance TTA as specified in Rel-17, this can implicitly indicate success of GNSS measurement.

Proposal 8: After UE re-acquires GNSS position fix in RRC connected, successful GNSS measurement is implicitly known in the following UL transmission.Proposal 9: If UE cannot re-acquire GNSS position fix in RRC connected after the GNSS validity duration expired and the configured timing/timer for autonomous GNSS reacquisition expired, it moves to RRC\_IDLE as in Rel-17. |
| Ericsson | Proposal 9: If the eNB receives the GNSS validity duration from the UE, it concludes that the UE’s latest GNSS measurement was successful. |
| Apple | Proposal 1: eNB notices the success of GNSS measurement at UE side via the reception of any UL transmission from the UE. |
| Qualcomm | Proposal 6: If the UE reacquires GNSS during an eNB-triggered GNSS measurement gap, and the GNSS reacquisition is unsuccessful:* If the previous GNSS validity duration has expired, the UE moves to IDLE / RLF recovery.
* If the previous GNSS validity duration has not expired, the UE is allowed to remain in RRC\_CONNECTED mode and inform the eNB of the remaining validity duration.
 |
| Lenovo | Proposal 6: UE is not expected to further explicitly report indication for success/completion of GNSS position fix, and the reception of any UL transmission from the UE at eNB side after the GNSS measurement can be an implicit way to report the success/completion of GNSS position fix. |

On success/failure of GNSS measurement, in RAN1 #112, it has been agreed that the following alternatives can be considered to inform eNB the success of GNSS measurement at UE side after GNSS measurement in RRC connected.

* Alt-1: The UE will report the new GNSS validity duration
* Alt-2: The reception of any UL transmission from the UE at eNB after the GNSS measurement

Besides, in Rel-17, RAN2 has agreed when the GNSS fix becomes outdated in RRC\_CONNECTED mode, the UE goes to IDLE mode. In this meeting, contributing companies provided views on this issue.

1. ***On success indication of GNSS measurement:***

Some contributing companies provided observations and proposals for all success indication of GNSS measurement before and after current GNSS validity duration expires

* OPPO proposed UE needs to perform RACH procedure after accomplishing the GNSS measurement to inform the eNB that the measurement is accomplished and after the UE GNSS re-acquisition the UE will start to monitor NPDCCH only after the UE sends the SR.
* CATT observed that UE is not necessary to report the new GNSS validity duration if it is same as old GNSS validity duration and proposed UE should send UL PRACH signal to indicate network when the GNSS measurement is successful.
* Nokia, NSB observed UE reporting the new GNSS validity duration after successful GNSS measurement enables a common understanding between UE and eNB while UE indicating successful GNSS measurement by any uplink transmission may cause network to attempt downlink transmission to a UE, which is no longer RRC connected. Nokia, NSB proposed the UE shall indicate success of the GNSS measurement by an explicit indication and RAN1 to discuss whether the UE can provide an explicit indication of successful GNSS measurement and optionally include the new GNSS validity duration, when the duration is different from the previous duration.
* Xiaomi mentioned UE reports the new GNSS validity duration after the successful GNSS measurement.
* Nordic Semiconductor ASA proposed after the GNSS measurement gap, the network may request UE to transmit a new GNSS validity duration value or a contention free (N)PRACH via (N)PDCCH order. Either one of those will implicitly inform the network that the GNSS measurement was successful.
* CMCC mentioned to inform eNB the success of acquiring GNSS position fix, the indication of success after GNSS measurement can be considered if implicit indication is not sufficient
* MediaTek mentioned after UE re-acquires GNSS position fix in RRC connected, successful GNSS measurement is implicitly known in the following UL transmission, where UE may trigger a RACH(wi/o scheduling request) or send HARQ ACK/NACK for DL packet at the end of the gap or at expiry of the timer or when UE enters into connected state of Connected DRX, to indicate success of GNSS position fix and report the new GNSS validity duration.
* Ericsson mentioned A UE in connected mode shall always report its GNSS validity duration after GNSS reacquisition and proposed if the eNB receives the GNSS validity duration from the UE, it concludes that the UE’s latest GNSS measurement was successful
* Lenovo mentioned UE is not expected to further explicitly report indication for success/completion of GNSS position fix, and the reception of any UL transmission from the UE at eNB side after the GNSS measurement can be an implicit way to report the success/completion of GNSS position fix.

Some contributing companies provided observations and proposals separately for success indication of GNSS measurement before and after current GNSS validity duration expires

*Option 1: On success indication of GNSS measurement after current GNSS validity duration expires*

* Huawei, HiSilicon mentioned the first NPUSCH scheduled by eNB after measurement gap can be used by UE to indicate the success of GNSS position fix.
* ZTE mentioned the GNSS measurement should be performed upon expiration of previous GNSS validity duration, which can maximize the utilization of each GNSS position fix and simplify the design. ZTE further proposed the reception of any UL transmission after GNSS measurement is preferred to indicate success/completion of GNSS position fix without additional signaling overhead and scheduling delay

*Option 2: On success indication of GNSS measurement before current GNSS validity duration expires*

* Huawei, HiSilicon mentioned UE could report the successful GNSS position fix when re-enter active state if UE re-acquires GNSS autonomously during the inactive state of UE’s C-DRX, with validity duration update, if applicable based on the measurement not triggered by network.
* Apple mentioned eNB notices the success of GNSS measurement at UE side via the reception of any UL transmission from the UE.
1. ***On failure of GNSS measurement:***

*On failure of GNSS measurement gap*

* Huawei, HiSilicon mentioned UE should stop UL transmission after measurement gap if GNSS position fix fails in the gap unless GNSS is re-acquired by other supported mechanism, e.g. autonomous GNSS measurement.
* OPPO proposed UE goes to idle if the GNSS acquisition fails within the measurement gap while UE expects the GNSS re-acquisition triggering from eNB within the GNSS validity duration as shown in Fig. 1 of R1-2302567.



Fig. 1: UE GNSS re-acquisition procedure when UE receives a triggering from eNB

* CMCC mentioned if UE cannot re-acquire the new GNSS position fix successfully until the GNSS validity duration expires, the UE goes to IDLE mode.
* ZTE mentioned the GNSS measurement should be performed upon expiration of previous GNSS validity duration, which can maximize the utilization of each GNSS position fix and simplify the design. ZTE further proposed the success indication of GNSS position fix should be transmitted within a time window after GNSS measurement and the GNSS position fix is thought failed if no success indication within the time window.
* Apple mentioned if the GNSS measurement failed but the validity duration is not expired, UE could send the remaining validity duration to network, eNB triggers a new GNSS measurement.
* Qualcomm mentioned if the UE reacquires GNSS during an eNB-triggered GNSS measurement gap, and the GNSS reacquisition is unsuccessful and if the previous GNSS validity duration has expired, the UE moves to IDLE / RLF recovery, if the previous GNSS validity duration has not expired, the UE is allowed to remain in RRC\_CONNECTED mode and inform the eNB of the remaining validity duration.

*On failure of GNSS measurement timer (autonomously GNSS measurement based on configured timing)*

* Huawei, HiSilicon mentioned UE can initiate a timer for autonomous GNSS measurement when GNSS validity duration and TAT (if supported) expires, and UE is not performing GNSS measurement triggered by eNB. UE enters idle mode if UE cannot reacquire GNSS before the timer expires.
* ZTE mentioned the GNSS measurement should be performed upon expiration of previous GNSS validity duration, which can maximize the utilization of each GNSS position fix and simplify the design. ZTE further proposed the success indication of GNSS position fix should be transmitted within a time window after GNSS measurement and the GNSS position fix is thought failed if no success indication within the time window.
* MediaTek mentioned if UE cannot re-acquire GNSS position fix in RRC connected after the GNSS validity duration expired and the configured timing/timer for autonomous GNSS reacquisition expired, it moves to RRC\_IDLE as in Rel-17.

Moderator View: To align understanding of UE and network, UE should indicate success of GNSS measurement. To the moderator understanding, the agreed alternatives can be considered to inform eNB the success of GNSS measurement. And if GNSS measurement failed before current GNSS validity duration expires, current GNSS position fix can still be used. On performing RACH procedure, to the moderator understanding, this can be detailed procedure for agreed alternatives. On failure of GNSS measurement, the agreement in Rel-17 that RAN2 has agreed when the GNSS fix becomes outdated in RRC\_CONNECTED mode, the UE goes to IDLE mode should be considered for Rel-18.

## 6.2 First Round Discussion

***Initial Proposal 6-1:***

***Companies are encouraged to down select one of the following alternatives to inform eNB the success of GNSS measurement at UE side after GNSS measurement in RRC connected and provide comments, where GNSS measurement finished after current GNSS validity duration expires:***

* + ***Alt-1: The reception of any UL transmission from the UE at eNB after GNSS measurement can inform eNB the success.***
	+ ***Alt-2: UE should report the new GNSS validity duration after accomplishing the GNSS measurement.***

***Initial Proposal 6-2:***

***If GNSS measurement finished before current GNSS validity duration expires, UE will report the new GNSS validity duration to inform eNB the success of GNSS measurement.***

***Initial Proposal 6-3:***

***Companies are encouraged to comment on:***

* ***Whether UL transmission is allowed before current GNSS validity duration expires in case UE failed to re-acquire GNSS position fix during the GNSS measurement gap in RRC\_CONNECTED mode.***
	+ - ***Note: The GNSS measurement gap ends before current GNSS validity duration expires.***
* ***Whether the UE goes to IDLE mode if UE failed to re-acquire GNSS position fix during configured timing/timer for autonomous GNSS reacquisition and current GNSS validity duration expired in RRC\_CONNECTED mode.***
* ***Whether the UE goes to IDLE mode if UE failed to re-acquire GNSS position fix during the eNB triggered GNSS measurement gap and current GNSS validity duration expired in RRC\_CONNECTED mode***

Companies are encouraged to provide comments within the following table:

|  |  |
| --- | --- |
| Companies | Comments |
| OPPO | Proposal 6-1: it is same as the previous agreement. Thus, maybe we don’t see this proposal. For down-selecting, we support Alt-2. Proposal 6-2: the proposal needs a re-wording: e.g. ***Initial Proposal 6-2-revised:******If GNSS measurement finished successfully before current GNSS validity duration expires, UE will report the new GNSS validity duration to inform eNB the success of GNSS measurement.***Proposal 6-3: If the GNSS validity duration is still valid, the UE should be still in sync. Thus, UL should be allowed. But when the GNSS validity duration expires, the UE can either go to idle (R17 behavior) or perform GNSS re-acquisition.  |
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# 7 [Active] Issue #7: GNSS measurement trigger

**Agreement (RAN1 109e)**

Further study on whether there is a need for potential enhancements on the following for long connection time

* UE triggered GNSS measurement.
* Network triggered GNSS measurement.

**Conclusion(RAN1 109e)**

IoT NTN UE may need to re-acquire a valid GNSS position fix in long connection time.

FFS: Whether and how to update or reduce the need to update GNSS position fix in long connection time

**Agreement (RAN1 110)**

When eNB triggers UE to make GNSS measurements, UE re-acquires GNSS position fix

* FFS details of signalling
* FFS how UE reports GNSS assistance information after eNB trigger and the detailed content
* Note: further discuss whether a UE is expected to handle all eNB triggers

**Agreement (RAN1 110bis-e)**

Support eNB to at least aperiodically trigger UE to make GNSS measurement.

**Agreement (RAN1 110bis-e)**

If eNB aperiodically triggers UE to make GNSS measurement, a MAC CE is used.

## 7.1 Company contributing views

|  |  |
| --- | --- |
| Contribution | Observation/Proposals |
| Huawei, HiSilicon | Proposal 10: UE may re-acquire GNSS autonomously on pre-configured occasions periodically. |
| Spreadtrum | Proposal 2: UE can send a request for network to trigger GNSS measurement aperiodically. |
| CATT | Proposal 1: Support UE initiatating a GNSS measurement with one request command when network triggering is not available.  |
| NEC | Proposal 2: Support periodic GNSS measurement to avoid expiry of GNSS validity duration during long UL repetition and to reduce signalling overhead where possible.Proposal 3: Support MAC CE design such that it can trigger both aperiodic and periodic GNSS measurements.Proposal 5: Support signalling transmission to the gNB to inform about UE triggered GNSS measurement. |
| Nokia, NSB | Observation 5: The UE may move in a predictable way, e.g. on a ship or train, and therefore make periodic GNSS measurements useful.Proposal 5: Support eNB to configure the UE to make periodic GNSS measurements.Proposal 6: Support eNB to broadcast multiple GNSS measurement configurations and UE to report which configuration it applies.Observation 6: If the UE does not transmit, the eNB is not aware of potential UE movement and therefore only the UE is able to determine the need for a new GNSS position fix and trigger aperiodic GNSS measurement.Observation 7: The UE may detect the mobility state change based on determining the time/frequency difference between a received downlink signal and an estimate based on the last known location.Proposal 7: Support the UE to request eNB to trigger at least an aperiodic GNSS measurement. |
| Xiaomi | Proposal 2: Periodical GNSS measurement can be supported. |
| Samsung | Proposal 2: Specify the condition of UE triggered GNSS measurement, e.g., GNSS validity timer is expired, there are UL data to transmit, and/or the UL synchronization is lost. |
| CMCC | Proposal 4. For GNSS measurement in RRC connected, GNSS measurement gap can also be configured periodically by network and indicated through RRC signalling. * UE may not perform GNSS measurement at each configured GNSS measurement gap, and the indication of not performing the GNSS measurement should be reported before the start of GNSS measurement gap.
 |
| ZTE | Proposal 3: No need to support UE sending a request for network to trigger GNSS measurement aperiodically.Proposal 4: No need to support additional periodically GNSS measurement on top of agreed timing/timer based GNSS measurement. |
| Apple | Proposal 3: RAN1 considers supporting periodic GNSS measurement timer for UE to re-acquire GNSS position for long connection times* if UE does not receive eNB triggered GNSS measurement until the periodic GNSS measurement timer is expired, UE performs GNSS measurement periodically
* Otherwise, periodic GNSS measurement timer is restarted from the starting subframe of the measurement gap according to eNB triggering singalling

Proposal 4: For timer-based periodic GNSS measurement, GNSS measurement gap and GNSS measurement periodicity are configured via aperiodic GNSS measurement triggering MAC CE. |
| Qualcomm | Proposal 5: If the UE receives a GNSS aperiodic trigger when the remaining GNSS validity duration is larger than Z, the UE is allowed to skip the GNSS reacquisition.• FFS: Details |
| Lenovo | Proposal 4: Triggering the GNSS measurement for both aperiodic and periodic way should be controlled by network.Proposal 5: UE can be configured with GNSS measurement gap with periodic way by RRC configuration. |

Contributing companies discussed on details of triggering signalling for GNSS measurement triggering as follows:

**On UE request eNB to trigger GNSS measurement:**

* Spreadtrum proposed UE can send a request for network to trigger GNSS measurement aperiodically.
* CATT mentioned to support UE initiating a GNSS measurement with one request command when network triggering is not available
* NEC mentioned to support signalling transmission to the gNB to inform about UE triggered GNSS measurement.
* Nokia observed if the UE does not transmit, the eNB is not aware of potential UE movement and therefore only the UE is able to determine the need for a new GNSS position fix and trigger aperiodic GNSS measurement and the UE may detect the mobility state change based on determining the time/frequency difference between a received downlink signal and an estimate based on the last known location. Nokia proposed to support the UE to request eNB to trigger at least an aperiodic GNSS measurement.
* Samsung proposed to specify the condition of UE triggered GNSS measurement, e.g., GNSS validity timer is expired, there are UL data to transmit, and/or the UL synchronization is lost.
* ZTE mentioned the motivation is to avoid the case where UE wants to keep in RRC\_CONNECTED mode but network does not trigger GNSS measurement. However, as UE autonomous GNSS re-acquisition has been agreed to be supported, UE can always have a chance to perform GNSS measurement before going to IDLE. ZTE further proposed no need to support UE sending a request for network to trigger GNSS measurement aperiodically.

**On periodically eNB trigger:**

* Huawei, HiSilicon mentioned UE may re-acquire GNSS autonomously on pre-configured occasions periodically.
* NEC proposed to support periodic GNSS measurement to avoid expiry of GNSS validity duration during long UL repetition and to reduce signalling overhead where possible with MAC CE.
* Nokia, NSB observed that UE may move in a predictable way, e.g. on a ship or train, and proposed to support eNB to configure the UE to make periodic GNSS measurements. Nokia, NSB further proposed to support eNB to broadcast multiple GNSS measurement configurations and UE to report which configuration it applies
* Xiaomi proposed periodical GNSS measurement should be supported
* CMCC proposed periodically GNSS measurement gap can be configured by network and indicated through RRC signalling and UE may not perform GNSS measurement at each configured GNSS measurement gap, and the indication of not performing the GNSS measurement should be reported before the start of GNSS measurement gap.
* ZTE mentioned the benefit of periodic GNSS measurement compared to aperiodic GNSS measurement is that only one trigger can be enough for multiple measurements, which saves the signaling overhead. However, since UE autonomous re-acquisition has already been agreed, where trigger signaling is not needed for each GNSS measurement, the benefit of additionally supporting periodic measurement is not clear. ZTE further proposed no need to support additional periodically GNSS measurement on top of agreed timing/timer based GNSS measurement.
* Apple mentioned periodic GNSS measurement timer is restarted from the starting subframe of the measurement gap according to eNB triggering singalling as shown in Figure1 of R1-2303502. Apple mentioned for timer-based periodic GNSS measurement, GNSS measurement gap and GNSS measurement periodicity are configured via aperiodic GNSS measurement triggering MAC CE.



Figure1: example of periodic GNSS measurement timer

* Lenovo mentioned UE can be configured with GNSS measurement gap with periodic way by RRC configuration controlled by network.

**On others:**

* Qualcomm mentioned if the UE receives a GNSS aperiodic trigger when the remaining GNSS validity duration is larger than Z, the UE is allowed to skip the GNSS reacquisition.

Moderator View: On a request from UE to trigger GNSS measurement, the UE by itself cannot know whether the timing error as measured at the eNB receiver is acceptable and potential UE movement without GNSS measurement. Besides, as contributing company mentioned, UE autonomous GNSS re-acquisition can help UE to perform GNSS measurement before going to IDLE. On periodically eNB trigger, the timer(s) based GNSS measurement in Issue 3 can be seen as an alternative similar to periodically eNB trigger mechanisms. eNB can predefine the Timer(s) for GNSS measurement, the Timer(s) can be reset once GNSS measurement completed. While for the periodically GNSS measurement, the network may need to re-configure the periodicity every time when new re-acquired GNSS validity duration changed or there will be resource waste issue if set the periodicity too short. Further understanding on this issue is needed. RAN1 can further think about whether UE is allowed to skip the GNSS reacquisition aperiodically triggered by network when the remaining GNSS validity duration is larger than some duration.

## 7.2 First Round Discussion

***Initial Proposal 7:***

***Companies are encouraged to comment on:***

* ***whether and when UE can send a request for network to trigger GNSS measurement aperiodically.***
* ***whether periodically GNSS measurement is needed with agreed timing/timer based GNSS measurement.***

Companies are encouraged to provide comments within the following table, if the answer is yes, please indicating why it is needed since RAN1 has already agreed “If eNB aperiodically triggers UE to make GNSS measurement, a MAC CE is used”:

|  |  |
| --- | --- |
| Companies | Comments |
| OPPO | We don’t see the need for periodic GNSS triggering, nor UE sends a request to trigger the GNSS. The UE can always perform autonomous GNSS re-acquisition under certain condition to avoid the case that UE has to go to idle due to the network not sending GNSS aperiodic triggering.  |
| Qualcomm | We do not see the need of any of these mechanisms. |
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# 8 [Low Priority] MISC

The WID objective is copied below for reminder

Study and specify needed improved GNSS operations for a new position fix for UE pre-compensation during long connection times and for reduced power consumption. Simultaneous GNSS and NTN NB-IoT/eMTC operation is not assumed. [RAN1, RAN2]

Based on the moderator understanding of the Rel-18 IoT NTN WID objectives and conclusions / agreements in Rel-17 IoT NTN Work Item, the following FL recommendations are made for sub-sections 8.1, 8.2.

## 8.1 Capability related to the non-simultaneously GNSS and NTN NB-IoT/eMTC operation

#### 8.1.1 Company contributing views

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| Contribution | Observation/Proposals |
| Xiaomi | Proposal 1: UE reports the capability related to the non-simultaneously GNSS and NTN NB-IoT/eMTC operation. |

Xiaomi commented simultaneously GNSS and NTN NB-IoT/eMTC operation is still not assumed in Rel-18 appears to have different understandings on the simultaneously GNSS and NTN NB-IoT/eMTC operation. One interpretation could be when a UE performs GNSS measurement, the cellular connection is completely released. While the other one interpretation could be when a UE performs GNSS measurement, it cannot perform data exchange while it is capable to maintain the cellular connection. Xiaomi further proposed to UE reports the capability related to the non-simultaneously GNSS and NTN NB-IoT/eMTC operation.

Moderator View: In TR 36.763 Section 5.2, it has been specified that GNSS capability in the UE is taken as a working assumption in this study for both NB-IoT and eMTC devices and imultaneous GNSS and NTN NB-IoT/eMTC operation is not assumed. Besides, simultaneous GNSS and NTN NB-IoT/eMTC operation is not assumed in Rel-18 IoT\_NTN\_enh WID. And further discussion on UE capability for Simultaneous GNSS and NTN NB-IoT/eMTC operation is not in scope of Rel-18.

#### 8.1.2 First Round Discussion

***FL recommendation 8.1:***

***Simultaneous GNSS and NTN NB-IoT/eMTC operation is not assumed in Rel-18 IoT\_NTN\_enh WID. Discussion on UE capability for Simultaneous GNSS and NTN NB-IoT/eMTC operation is not in scope of Rel-18.***

Companies are encouraged to provide comments on the FL recommendation within the following table:

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| Companies | Comments |
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## 8.2 PDCCH order/DCI-based GNSS measurement trigger

#### 8.2.1 Company contributing views

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| --- | --- |
| Contribution | Observation/Proposals |
| Samsung | Proposal 4: For aperiodic GNSS measurement, PDCCH order/DCI based triggering signaling should be supported. |

Samsung observed for aperiodic GNSS measurement should be triggered in the case that GNSS measurement validation is out-dated and UL synchronization is lost. In this case, the UE cannot send HARQ-ACK for the triggering signaling conveyed by MAC CE. Thus, eNB cannot sure whether the triggering signaling is successfully received by the UE. Therefore, DCI based triggering signaling should be supported for this case. In addition, after GNSS measurement is completed and new GNSS position fix is obtained, PRACH will be transmitted for the purpose of UL resynchronization. So, the DCI used for indication of PDCCH order RACH can also be used to trigger a new GNSS measurement, e.g., implicit indication without any change for all of the DCI fields, or using some reserved bit(s) in the DCI. And, the PDCCH order RACH can be initiated after completing GNSS measurement by the UE.

Moderator View: On PDCCH order/DCI-based trigger, as companies mentioned in past few meetings that GNSS position fix trigger will be a rather infrequent case, the agreed MAC CE is enough and DCI-based solution may involve large spec impact (e.g. new DCI field).

#### 8.2.2 First Round Discussion

***FL recommendation 8.2:***

***Proponents for PDCCH order/DCI-based GNSS measurement trigger are encouraged to further discuss offline to get more support.***

Companies are encouraged to provide comments on the FL recommendation within the following table:

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| Companies | Comments |
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# 9 Proposals for online/offline discussions

# 10 Conclusion

# 11 References

1. RP-223519, Moderator (MediaTek), Revised WID on IoT NTN enhancements, 12-16 December, 2022
2. R1-2302367, Discussion on improved GNSS operations for IoT NTN, Huawei, HiSilicon
3. R1-2302567, Discussion on improved GNSS operations for IoT NTN, OPPO
4. R1-2302618, Discussion on improved GNSS operations for IoT NTN, Spreadtrum Communications
5. R1-2302722, Discussion on remaining issues of improved GNSS operations for IoT NTN, CATT
6. R1-2302749, On Improved GNSS Operations for IoT NTN, NEC
7. R1-2302838, Enhancements for long connections in NB-IoT/eMTC over NTN, Nokia, Nokia Shanghai Bell
8. R1-2303001, Discussion on the improved GNSS operation for IoT NTN, xiaomi
9. R1-2303147, Improved GNSS operations for IoT NTN, Samsung
10. R1-2303176, Improved GNSS operation for IoT NTN, Nordic Semiconductor ASA
11. R1-2303252, Discussion on improved GNSS operations for IoT NTN, CMCC
12. R1-2303297, Discussion on improved GNSS operation for IoT-NTN, ZTE
13. R1-2303358, Improved GNSS operations for IoT NTN, MediaTek Inc.
14. R1-2303432, On Improved GNSS operation in IoT NTN, Ericsson Limited
15. R1-2303502, On improved GNSS operations for IoT NTN, Apple
16. R1-2303543, Improved GNSS operations for IoT NTN, InterDigital, Inc.
17. R1-2303609, Improved GNSS Operations for IoT-NTN, Qualcomm Incorporated
18. R1-2303628, Improved GNSS operations for IoT NTN, Lenovo