**3GPP TSG RAN WG1 Meeting #113 R1-2305998**

**Incheon, Korea, May 22nd – May 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

## 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.)

|  |  |  |
| --- | --- | --- |
| Company | Name | E-mail |
| OPPO | Hao Lin | lin.hao@oppo.com |
| Lockheed | Robert Olesen | robert.l.olesen@lmco.com |
| Lenovo | Zhi, Yan | yanzhi1@lenovo.com |
| ZTE | Fangyu Cui | cui.fangyu@zte.com.cn |
| Qualcomm | Ayan Sengupta | asengupt@qti.qualcomm.com |
| CATT | Deshan Miao | miaodeshan@catt.cn |
| Xiaomi | Yajun Zhu | zhuyajun@xiaomi.com |
| Nokia, NSB | Jingyuan Sun | Jingyuan.sun@nokia-sbell.com |
| Samsung | Min Wu | min1.wu@samsung.com |
| Samsung | Carmela Cozzo | carmela.c@samsung.com |
| CMCC | Wei Qin | qinwei@chinamobile.com |
| Nordic | Mauri Nissila | mauri.nissila@nordicsemi.no |
| Huawei, HiSilicon | Xiaolei TIE | tiexiaolei@huawei.com |
| Huawei, HiSilicon | Xinghua Song | songxinghua@huawei.com |
| SONY | Martin Beale | martin.beale@sony.com |
| Apple | Chunxuan Ye | Chunxuan\_ye@apple.com |
| Apple | Chunhai Yao | Chunai\_yao@apple.com |
| Spreadtrum | Zhenzhu Lei | reven.lei@unisoc.com |
| MediaTek | Wen Tang | WenT.Tang@mediatek.com |
| Ericsson | Talha Khan | talha.khan@ericsson.com |
| Ericsson | Olof Liberg | olof.liberg@ericsson.com |
| InterDigital | Moon-il Lee | Moonil.lee@interdigital.com  |
| Sequans | Efstathios Katranaras | ekatranaras@sequans.com |
| Qualcomm | Alberto Rico | albertor@qti.qualcomm.com  |

# [Active] Issue #1: UL transmission after original GNSS validity duration expires 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

**RAN2-121bis**

1. UE can stay in RRC\_CONNECTED state when current GNSS position becomes out-of-date if the UE enters a GNSS measurement gap. FFS whether the new GNSS measurement shall be started before, upon or after the current GNSS validity duration expiry

## Company contributing views

|  |  |
| --- | --- |
| Contribution | Observation/Proposals |
| 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: For UL transmission after original GNSS validity duration expires without GNSS re-acquisition for some duration, the duration is one value/timer configured by network.Proposal 5: legacy closed loop time correction does not need to be enhanced. |
| Huawei, HiSilicon | Proposal 7: UL transmission can be allowed in a duration X after original GNSS validity duration expires without GNSS re-acquisition. The duration X is determined by the remaining time of timeAlignmentTimerObservation 1: Further enhancement on the Close loop time and frequency error correction is not needed during the connection for IoT NTN. |
| Nokia, NSB | Observation 7: the eNB may detect that the UE’s uplink transmission is well aligned despite the GNSS validity duration expiry is approaching.Observation 8: the eNB may transmit a Timing Advance Command prior to the GNSS validity duration expiry without intending to extend the GNSS validity duration expiry by the corresponding restart of the timeAlignmentTimer.Proposal 11: The network can configure a value for the extension of the GNSS validity duration. |
| CATT | Proposal 4: It is not necessary to support UL transmission after original GNSS validity duration expires without GNSS re-acquisition. |
| 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. |
| Xiaomi | Proposal 5: Closed loop frequency control can be supported to avoid frequent GNSS measurement. |
| NEC | Proposal 1: Closed-loop correction during long UL repetition is not needed for IoT NTN. |
| Apple | Proposal 1: eNB indicates the time period dynamically to continue the UL transmission after GNSS validity duration expires. |
| Sharp | Proposal 1: When frequency error is within frequency error requirements and timeAlignmentTimer is not expired, the GNSS validity duration, if expires, can be extended based on the remaining TAT. |
| 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 7: 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.

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 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 8: 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

Proposal 9: Upon reception of a closed loop command with the purpose of “allowing UL transmission after original GNSS validity duration expires without GNSS re-acquisition for some duration”, the UE starts a closed loop timer:* The UE moves back to IDLE or re-acquires GNSS (if autonomous gaps are configured) if both the closed loop timer and the GNSS validity duration are expired.
 |
| 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. |
| ZTE | Proposal 1: To allow UL transmission in a duration after original GNSS validity duration expires without GNSS re-acquisition, eNB can indicate an extension duration 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 duration indicated by eNB.
* The behaviors upon expiration of GNSS validity duration will keep unchanged no matter whether GNSS validity duration 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.Proposal 2: It is up to RAN2 to decide whether the duration, where UE can be allowed to have UL transmission without GNSS re-acquisition after GNSS validity duration expires, is extended GNSS validity duration or another timer. |
| Nordic Semiconductor ASA | Proposal 1: In RRC connected mode, the closed loop time and frequency correction loops could be considered as a complementary mechanism to GNSS gaps. |
| 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 (where X is FFS).Proposal 2: RAN2 to decide whether the GNSS extension duration X is configured by directly extending the GNSS validity duration or by introducing a new validity duration/timer.Proposal 3: Network to optionally indicate UE-specific timing drift parameters to an IoT NTN UE in connected mode. Proposal 4: 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 5: Closed loop frequency correction mechanism shall not be specified unless absolutely necessary. |

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. And in RAN1 #112-bis meeting, the issue has been discussed a lot on RAN1 reflector without final consensus. UL transmission after GNSS validity duration expires and potential enhancements are discussed by contributing companies.

1. **UL transmission within some duration after GNSS validity duration expire with legacy Closed loop time correction**

Huawei, HiSilicon, Sharp, Qualcomm, MediaTek preferred some duration is based on the remaining TAT.

Spreadtrum, Nokia, NSB, Apple, ZTE, Ericsson preferred some duration is other value/timer configured by network.

* Spreadtrum mentioned 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
* Huawei, HiSilicon proposed UL transmission can be allowed in a duration X after original GNSS validity duration expires without GNSS re-acquisition. The duration X is determined by the remaining time of timeAlignmentTimer. Huawei, HiSilicon mentioned a UE receives a TAC before the end of the reported GNSS validity duration and the corresponding TAC is still valid according to timeAlignmentTimer (TAT) after the original reported GNSS validity duration expires. In such case, accuracy of UL synchronization is still sufficient for UL transmission at least before TAT expires. Moreover, if UE receive another TAC within the validity of the previous TAC, the valid time for UL transmission can be further extended to the end of the subsequent TAC validity as illustrated in Fig.2 of R1-2304635.



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

* Nokia, NSB observed the eNB may detect that the UE’s uplink transmission is well aligned despite the GNSS validity duration expiry is approaching and the eNB may transmit a Timing Advance Command prior to the GNSS validity duration expiry without intending to extend the GNSS validity duration expiry by the corresponding restart of the timeAlignmentTimer. Nokia, NSB further proposed the network can configure a value for the extension of the GNSS validity duration.
* CATT mentioned It is not necessary to support UL transmission after original GNSS validity duration expires without GNSS re-acquisition.
* Apple proposed eNB indicates the time period dynamically to continue the UL transmission after GNSS validity duration expires.
* Sharp proposed When frequency error is within frequency error requirements and timeAlignmentTimer is not expired, the GNSS validity duration, if expires, can be extended based on the remaining TAT.
* Qualcomm proposed 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 and if closed loop corrections are used, the UE is allowed to perform UL transmission after original GNSS validity duration expires. Qualcomm further proposed Upon reception of a closed loop command with the purpose of “allowing UL transmission after original GNSS validity duration expires without GNSS re-acquisition for some duration”, the UE starts a closed loop timer and the UE moves back to IDLE or re-acquires GNSS (if autonomous gaps are configured) if both the closed loop timer and the GNSS validity duration are expired as depicted in Fig 2 of R1-2305355.

GNSS fix

Validity expires

CL command

CONN

CL command

IDLE

CL timer

GNSS validity duration

CL timer expires

Figure 2: Diagram showing the interaction of closed loop commands and validity duration: the UE moves to IDLE (or reacquires GNSS) upon expiration of both the CL timer and validity duration.

* ZTE mentioned to allow UL transmission in a duration after original GNSS validity duration expires without GNSS re-acquisition, eNB can indicate an extension duration 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 duration indicated by eNB. The behaviors upon expiration of GNSS validity duration will keep unchanged no matter whether GNSS validity duration is extended by eNB or not.
* MediaTek proposed 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 and it is up to RAN2 to decide whether the duration, where UE can be allowed to have UL transmission without GNSS re-acquisition after GNSS validity duration expires, is extended GNSS validity duration or another timer.
* Ericsson mentioned 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 (where X is FFS) and RAN2 to decide whether the GNSS extension duration X is configured by directly extending the GNSS validity duration or by introducing a new validity duration/timer.
1. **Other potential enhancements:**

Contributing companies mentioned on views of potential enhancements:

Spreadtrum, Huawei, HiSilicon, NEC, Lenovo preferred no further closed loop correction enhancements.

* 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 R1-2304635 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 R1-2304919 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. Xiaomi further proposed Closed loop frequency control can be supported to avoid frequent GNSS measurement.



Figure 1: TA error due to the UE movement



Figure 2: Doppler shift due to the UE movement

* NEC mentioned closed-loop correction during long UL repetition is not needed for IoT NTN.
* Qualcomm observed that 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. 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
* Samsung proposed to Support closed loop correction for pre-compensated frequency offset, e.g., absolute frequency command and/or frequency adjustment command can be considered.
* Nordic Semiconductor ASA mentioned In RRC connected mode, the closed loop time and frequency correction loops could be considered as a complementary mechanism to GNSS gaps.
* 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 R1-2305916 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
 |  |

Ericsson further mentioned Network to optionally indicate UE-specific timing drift parameters to an IoT NTN UE in connected mode and 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 and Closed loop frequency correction mechanism shall not be specified unless absolutely necessary.

Moderator View: RAN1 can first align understanding on that at least for the case when frequency error and timing error are within frequency and timing error requirements with legacy closed loop time correction, UL transmission can be allowed in a duration X after original GNSS validity duration expires without GNSS re-acquisition. To the moderator understanding, RAN2 can further discuss whether X is extended GNSS validity duration or new timer and whether X is remaining timeAlignmentTimer or one value configured by network. Whether closed loop time and frequency correction with potential enhancements are needed can be discussed after progress is made for the first one.

## First Round Discussion

**Initial Proposal 1:**

**From RAN1 perspective, at least for the case when frequency error and timing error are within frequency and timing error requirements with legacy closed loop time correction, UL transmission can be allowed in a duration X after original GNSS validity duration expires without GNSS re-acquisition.**

***RAN2 can further discuss whether X is configured by network or whether X is based on remaining timeAlignmentTimer value.***

Companies are encouraged to provide comments within the following table:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson | Support |
| Qualcomm | Support |
| Nordic | Support |
| ZTE | The solution will impact the start time of GNSS measurement timer, which is being discussed in UE autonomous GNSS acquisition. RAN1 may also need to discuss this issue. |
| Spreadtrum | Support |
| Huawei, HiSilicon | support |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# [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

**Agreement (RAN1 112bis)**

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

* 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 included in the configuration by eNB.

**Agreement (RAN1 112bis)**

On when the aperiodic GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, 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, considering HARQ feedback for the MAC CE, etc

## Company contributing views

|  |  |
| --- | --- |
| Contribution | Observation/Proposals |
| Spreadtrum | Proposal 1: The start time should be at n+ 12, where n is the end of MAC CE receiving subframe/slot. |
| Huawei, HiSilicon | Proposal 1: When the aperiodic GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, the start time should be from the end of n+12 DL subframe, where n is the end of MAC CE receiving subframe/slot.Proposal 2: If UE does not decode the triggering MAC CE correctly, a NACK should be sent by UE on the NPUSCH format 2 resource indicated by scheduling DCI. |
| Nokia, NSB | 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.Proposal 2: The start time of the aperiodically triggered GNSS measurement gap shall be based on the receiving time of the trigger indication and consider the time required by the UE to provide HARQ feedback to guarantee there is common understanding between UE and network on the gap. |
| Xiaomi | Proposal 2: The start of the measurement gap is indicated in the triggering command. |
| 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. On when the aperiodic GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot, * X can be the DL processing time for NB-IoT/eMTC NTN.
 |
| Apple | Proposal 2: For aperiodic triggered GNSS measurement, the DL HARQ with MAC CE activating GNSS position fix can not be disabled. Proposal 3: For aperiodic triggered GNSS measurement, UE performs the GNSS measurement after $n+k\_{0}^{'}+K\_{offset}+3-1$ms, where n is the ending DL subframe where the MAC CE is received.  |
| Qualcomm | Proposal 3: On the starting time of the GNSS measurement gap, which is aperiodically triggered by eNB via MAC CE, the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot.* X is X1ms after the end of the (N)PDSCH carrying the MAC-CE if HARQ feedback is disabled, and X2ms after the end of the transmission of the HARQ-ACK if HARQ feedback is enabled.
 |
| OPPO | Proposal 1: For determining aperiodic GNSS measurement gap start time, adopt X=12.Observation 1: 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 2: 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 3: UE expects the GNSS re-acquisition triggering from eNB within the GNSS validity duration. |
| 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. |
| ZTE | Proposal 2: The aperiodic GNSS measurement gap starts at n+X, where n is the end of MAC CE receiving subframe and X is configured by network. |
| MediaTek | Proposal 6: 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 7: The GNSS measurement gap offset is configured in GNSS measurement trigger MAC CE. |
| Nordic Semiconductor ASA | Proposal 3: 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. |
| 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 6: If eNB aperiodically triggers UE to make GNSS measurement, RRC signalling is used.Proposal 9: Network to configure the GNSS measurement gap duration from the following set of values: {1, 2, 5, X} seconds, where X is FFS.Proposal 10: If the starting instance of an aperiodic GNSS measurement gap is n+X, where n is the end of the downlink subframe/slot containing the MAC CE for an aperiodic GNSS trigger, the value X can be set to a pre-defined value unless configured explicitly by the network.Observation 10: If the starting instance of an aperiodic GNSS measurement gap is n+X, where n is the end of the downlink subframe/slot containing the MAC CE for an aperiodic GNSS trigger, X should be chosen to support cases with HARQ feedback enabled as well as disabled.Observation 11: The minimum value of X to be supported can be based on the minimum processing time that a UE needs to decode the GNSS trigger command carried by the (N)PDSCH.Observation 12: An NB-IoT UE is allowed up to 12 ms to decode the GNSS trigger command carried by an NPDSCH whereas an eMTC UE has 3 ms to decode the GNSS trigger command carried by a PDSCH.Proposal 11: If the starting instance of an aperiodic GNSS measurement gap is n+X where n is the end of the downlink subframe/slot containing the MAC CE for an aperiodic GNSS trigger, then the minimum configurable value of X is 3 subframes for eMTC and 12 subframes for NB-IoT when HARQ feedback is disabled for the (N)PDSCH carrying the MAC CE containing the GNSS trigger.Observation 13: An eMTC UE can be configured with up to 8, up to 10, or up to 14 HARQ processes.Observation 14: For eMTC, up to 3 PUCCHs may be needed to transmit HARQ feedback if HARQ ACK bundling is used.Proposal 12: GNSS measurement gap can start after the end of the subframe/slot used for transmitting the last PUCCH.Observation 15: To cater to different scenarios, the description of “X” can be generalized in terms of the HARQ-ACK delay and the number of PUCCHs to be transmittedProposal 13: For eMTC NTN with HARQ feedback enabled for all HARQ processes, if the starting instance of an aperiodic GNSS measurement gap is n+X where n is the end of the downlink subframe/slot containing the MAC CE for an aperiodic GNSS trigger, then X = HARQ-ACK delay + (#PUCCHs not overlapping with the HARQ-ACK delay) + 1.Observation 16: An NB-IoT UE can be configured with up to 2 HARQ processes.Observation 17: When two HARQ processes are configured, the GNSS measurement command can be carried by either the first or the second HARQ process.Observation 18: The length of an NPUSCH Format 2 resource unit is 2 ms for a subcarrier spacing of 15 kHz and 8 ms for a subcarrier spacing of 3.75 kHz.Proposal 14: For NB-IoT NTN with HARQ feedback enabled for all HARQ processes, if the starting instance of an aperiodic GNSS measurement gap is n+X where n is the end of the downlink subframe/slot containing the MAC CE for an aperiodic GNSS trigger, then $X=\left\{\begin{array}{c}k\_{0}+RU\_{length},  \&1 HARQ process only; \\k\_{0\_{\\_HARQ\#0}}+k\_{0\_{\\_HARQ\#1}}-\left(k\_{0\_{\\_HARQ\#1}}-NSF\_{HARQ\#1 }\right)+RU\_{length},  \&2 HARQ processes,"GNSS trigger" on HARQ 0;\\k\_{0\_{\\_HARQ\#1}}+RU\_{length},  \&2 HARQ processes,"GNSS trigger" on HARQ 1;\end{array}\right.$ where “k0” is obtained from Table 16.4.2-1 or Table 16.4.2-2 of TS 36.213 when NPUSCH Format 2 uses a 3.75 kHz or a 15 KHz subcarrier spacing, RU\_length is the length of an NPUSCH Format 2 resource unit, and “NSF” is the number of NPDSCH subframes.Proposal 15: For IoT NTN, the design of the GNSS start time should also consider the hybrid scenarios where HARQ feedback is enabled for some and disabled for other HARQ processes. Details are FFS. |

In RAN1 #112bis, it was agreed that For the GNSS measurement gap aperiodically triggered with MAC CE, the duration for the GNSS measurement gap can be configured by eNB and 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 included in the configuration by eNB. Besides, on when the GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot.

Contributing companies discussed for the start position and network configuration of the gap duration.

1. ***configuration of GNSS measurement gap***
* Xiaomi mentioned the start of the measurement gap is indicated in the triggering command.
* CMCC mentioned 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
* OPPO mentioned UE expects the GNSS re-acquisition triggering from eNB within the GNSS validity duration as shown in Fig. 1 of R1-2305439.



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

* 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.
* MediaTek proposed The GNSS measurement gap offset is configured in GNSS measurement trigger MAC CE.
* 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.
1. ***start position of*** ***GNSS measurement gap***

Spreadtrum, Huawei, HiSilicon, CMCC, OPPO, ZTE, Nordic Semiconductor ASA preferred X equals to one common value should be utilized for both HARQ feedback enabled and disabled cases for the MAC CE.

Qualcomm, Ericsson preferred X equals to Rel-18 scheduling delay when HARQ feedback for the MAC CE is enabled or disabled, plus some offset.

Nokia, NSB, Apple, MediaTek preferred one value where HARQ feedback should always be enabled for aperiodic GNSS measurement gap trigger MAC CE.

* Spreadtrum mentioned the start time should be at n+ 12, where n is the end of MAC CE receiving subframe/slot.
* Huawei, HiSilicon mentioned When the aperiodic GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, the start time should be from the end of n+12 DL subframe, where n is the end of MAC CE receiving subframe/slot and if UE does not decode the triggering MAC CE correctly, a NACK should be sent by UE on the NPUSCH format 2 resource indicated by scheduling DCI.
* Nokia, NSB mentioned 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 start time of the aperiodically triggered GNSS measurement gap shall be based on the receiving time of the trigger indication and consider the time required by the UE to provide HARQ feedback to guarantee there is common understanding between UE and network on the gap.
* Apple mentioned for aperiodic triggered GNSS measurement, the DL HARQ with MAC CE activating GNSS position fix can not be disabled and UE performs the GNSS measurement after $n+k\_{0}^{'}+K\_{offset}+3-1$ms, where n is the ending DL subframe where the MAC CE is received.
* CMCC mentioned on when the aperiodic GNSS measurement gap starts, which is aperiodically triggered by eNB with MAC CE, the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot, X can be the DL processing time for NB-IoT/eMTC NTN.
* Qualcomm mentioned on the starting time of the GNSS measurement gap, which is aperiodically triggered by eNB via MAC CE, the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot where X is X1ms after the end of the (N)PDSCH carrying the MAC-CE if HARQ feedback is disabled, and X2ms after the end of the transmission of the HARQ-ACK if HARQ feedback is enabled.
* OPPO proposed for determining aperiodic GNSS measurement gap start time, adopt X=12.
* ZTE mentioned the aperiodic GNSS measurement gap starts at n+X, where n is the end of MAC CE receiving subframe and X is configured by network.
* 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.
* 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.
* Ericsson mentioned if the starting instance of an aperiodic GNSS measurement gap is n+X, where n is the end of the downlink subframe/slot containing the MAC CE for an aperiodic GNSS trigger, the value X can be set to a pre-defined value unless configured explicitly by the network and if the starting instance of an aperiodic GNSS measurement gap is n+X, where n is the end of the downlink subframe/slot containing the MAC CE for an aperiodic GNSS trigger, X should be chosen to support cases with HARQ feedback enabled as well as disabled where the minimum value of X to be supported can be based on the minimum processing time that a UE needs to decode the GNSS trigger command carried by the (N)PDSCH. For IoT NTN, the design of the GNSS start time should also consider the hybrid scenarios where HARQ feedback is enabled for some and disabled for other HARQ processes. Details are FFS.

For HARQ feedback disabled, Ericsson observed An NB-IoT UE is allowed up to 12 ms to decode the GNSS trigger command carried by an NPDSCH whereas an eMTC UE has 3 ms to decode the GNSS trigger command carried by a PDSCH and proposed If the starting instance of an aperiodic GNSS measurement gap is n+X where n is the end of the downlink subframe/slot containing the MAC CE for an aperiodic GNSS trigger, then the minimum configurable value of X is 3 subframes for eMTC and 12 subframes for NB-IoT when HARQ feedback is disabled for the (N)PDSCH carrying the MAC CE containing the GNSS trigger.

For HARQ feedback enabled, Ericsson observed An eMTC UE can be configured with up to 8, up to 10, or up to 14 HARQ processes. For eMTC, up to 3 PUCCHs may be needed to transmit HARQ feedback if HARQ ACK bundling is used and proposed GNSS measurement gap can start after the end of the subframe/slot used for transmitting the last PUCCH. To cater to different scenarios, the description of “X” can be generalized in terms of the HARQ-ACK delay and the number of PUCCHs to be transmitted. For eMTC NTN with HARQ feedback enabled for all HARQ processes, if the starting instance of an aperiodic GNSS measurement gap is n+X where n is the end of the downlink subframe/slot containing the MAC CE for an aperiodic GNSS trigger, then X = HARQ-ACK delay + (#PUCCHs not overlapping with the HARQ-ACK delay) + 1. An NB-IoT UE can be configured with up to 2 HARQ processes.When two HARQ processes are configured, the GNSS measurement command can be carried by either the first or the second HARQ process.The length of an NPUSCH Format 2 resource unit is 2 ms for a subcarrier spacing of 15 kHz and 8 ms for a subcarrier spacing of 3.75 kHz.For NB-IoT NTN with HARQ feedback enabled for all HARQ processes, if the starting instance of an aperiodic GNSS measurement gap is n+X where n is the end of the downlink subframe/slot containing the MAC CE for an aperiodic GNSS trigger, then

$X=\left\{\begin{array}{c}k\_{0}+RU\_{length},  \&1 HARQ process only; \\k\_{0\_{\\_HARQ\#0}}+k\_{0\_{\\_HARQ\#1}}-\left(k\_{0\_{\\_HARQ\#1}}-NSF\_{HARQ\#1 }\right)+RU\_{length},  \&2 HARQ processes,"GNSS trigger" on HARQ 0;\\k\_{0\_{\\_HARQ\#1}}+RU\_{length},  \&2 HARQ processes,"GNSS trigger" on HARQ 1;\end{array}\right.$

where “k0” is obtained from Table 16.4.2-1 or Table 16.4.2-2 of TS 36.213 when NPUSCH Format 2 uses a 3.75 kHz or a 15 KHz subcarrier spacing, RU\_length is the length of an NPUSCH Format 2 resource unit, and “NSF” is the number of NPDSCH subframes.

1. ***others***
* OPPO mentioned 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 and the GNSS measurement gap has often long duration, the configured SPS may cause a waste of spectrum efficiency. OPPO proposed after the UE GNSS re-acquisition the UE will start to monitor NPDCCH only after the UE sends the SR. To the moderator understating, the network knows when the gap end, and network can have DL scheduling after the end of gap.
* 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 RAN2 has agreed For the NB-IoT CP solution, UE will report the GNSS validity duration by using a MAC CE in RAN2 121bis, whether to add RRC signalling can be discussed in RAN2.

Moderator View: On the configuration of GNSS measurement gap, RAN1 can further discuss the detailed configuration once conclusions on the detailed component values of GNSS position fix time duration for measurement has been made and for the configuration signalling, RAN1 can wait for RAN2 progress. On when the GNSS measurement gap starts, RAN1 can first discuss whether a common value should be utilized regardless of HARQ feedback enabled or disabled for the MAC CE, or different values respectively for HARQ feedback enabled and disabled for the MAC CE or one value where HARQ feedback should always be enabled for aperiodic GNSS measurement gap trigger MAC CE, then details can be discussed later.

## First Round Discussion

***Initial Proposal 2:***

***For the aperiodic GNSS measurement gap triggered by eNB with MAC CE, the start time should be at n+ X, where n is the end of MAC CE receiving subframe/slot and X>= 12ms for NB-IoT, X>= 3ms for eMTC, down select one of the following***

* ***Alt 1: X is one common value regardless of HARQ feedback enabled or disabled for the MAC CE***
	+ ***FFS: details, e.g. X is predefined value or configured value***
* ***Alt 2: X is different values considering different scheduling delay of HARQ feedback enabled and disabled for the MAC CE***
	+ ***FFS: details of X, e.g. X= scheduling delay + X’, where scheduling delay is different when HARQ feedback enabled and disabled***
* ***Alt 3: X is one value where HARQ feedback should be always enabled for the MAC CE***
	+ ***FFS: details of X***

Companies are encouraged to provide comments within the following table:

|  |  |  |
| --- | --- | --- |
| Companies | Alt 1/Alt 2/Alt 3 | Comments |
| Ericsson | Alt 2 | Please note that the UE may be configured with multiple HARQ processes (up to 2 for NB-IoT and up to 8/10/14 for eMTC) including the one carrying the GNSS trigger. Plus, it is up to the network whether to enable or disable the HARQ feedback for a HARQ process. In principle, GNSS gap can be started once HARQ feedback has been transmitted. Therefore, different values of X will be needed depending on the number of HARQ processes and whether HARQ feedback is enabled or disabled.  |
| Qualcomm | Alt 2 |  |
| Nordic | Alt2 | We are fine also with Alt3 |
| ZTE | Alt 2 | With alt 2, network can determine whether a HARQ-ACK is needed up to implementation. For details, we think direct configuration of X via several candidate values may be enough. No need to design complex formula for different cases. |
| CMCC | Alt2 | HARQ feedback enabled and disabled can be configured by network, and different values of delay for different configuration can be considered respectively. |
| Spreadtrum | Alt 1 or Alt 2 |  |
| Huawei, HiSilicon | Alt 1 at least for NBIoT | Alt 1 is the legacy NB IoT behavior. We also think wait for ACK response is not necessary because UE will feedback validity duration anyway after successful GNSS measurement in the gap. The overhead on long NPUSCH transmission is another concern.  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

# [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

|  |  |
| --- | --- |
| 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 after autonomous GNSS measurement timer expires.Proposal 9: For autonomous GNSS measurement, the length of GNSS measurement timer for autonomous GNSS re-acquisition is configured by network. If not configured, it equals to the latest reported GNSS position fix time duration for measurement.  |
| Nokia, NSB | Observation3: The UE may move in a predictable way, e.g. on a ship or train, and therefore make periodic GNSS measurements useful.Proposal 3: Support eNB to configure the UE to make periodic GNSS measurements.Proposal 4: Support eNB to broadcast multiple GNSS measurement configurations and UE to report which configuration it applies.Proposal 5: Autonomous GNSS measurement may be supported as complenary to periodic and aperiodic GNSS measurement.Proposal 6: Before RAN1 to support autonomous GNSS measurement, it should firsly decided how to make a common understanding between UE and network on whether UE will do it in each time.Proposal 7: The length of the GNSS measurement timer for autonomous GNSS re-acqusition is equal to the length of the network-configured GNSS measurement gap.Proposal 8: For UE autonomous GNSS measurements, the start time shall be based on the current GNSS validity duration with a network-configured offset.Observation 6: There may be a need for a GNSS measurement during a long period of downlink/uplink repetitions.Proposal 10: RAN1 to discuss handling a GNSS measurement during a long period of downlink/uplink repetitions. |
| CATT | Proposal 3: If UE is allowed to perform GNSS measurement autonomously, eNB should send the enabling indication to UE and assume the GNSS validity duration as default timer to control UE’s measurement. |
| 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. |
| Lenovo | Proposal 2: Triggering the GNSS measurement for both aperiodic and periodic way should be controlled by network.Proposal 3: UE can be configured with GNSS measurement gap with periodic way by RRC configuration. |
| Xiaomi | Proposal 3: Periodical GNSS measurement can be supported. |
| 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 4: The UE may re-acquire GNSS autonomously based on configured timing if it does not receive eNB trigger to make GNSS measurement.Proposal 5: Support signalling transmission to the gNB to inform about UE triggered GNSS measurement. |
| CMCC | Proposal 3. 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.

Proposal 4. For autonomous GNSS measurement if UE does not receive eNB triggering to make GNSS measurement, UE can start to re-acquire GNSS position fix when current GNSS validity duration expires, and the time duration for autonomous GNSS measurement is equal to the UE reported GNSS position fix time duration. |
| Apple | Proposal 5: 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 6: For timer-based periodic GNSS measurement, GNSS measurement gap and GNSS measurement periodicity are configured via aperiodic GNSS measurement triggering MAC CE. |
| Sharp | Proposal 2: For autonomous GNSS re-acquisition, the UE may re-acquire GNSS autonomously during GNSS measurement timer, * The length of GNSS measurement timer for autonomous GNSS re-acquisition is configured by network.
* The start time of the autonomous GNSS measurement timer is based on GNSS validity duration with a delay.

Proposal 5. Periodically eNB trigger is not supported. |
| Qualcomm | Proposal 6: The start time of a UE-autonomous GNSS measurement gap is defined with respect to the end of the GNSS validity duration.* FFS: details.
 |
| 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. |
| ZTE | Proposal 3: UE may re-acquire GNSS autonomously based on periodic GNSS measurement gap if UE does not receive eNB trigger to make aperiodic GNSS measurement. |
| MediaTek | Observation 1: On UE autonomously re-acquiring GNSS measurement mechanism, configured timing are flexible duration is better.Observation 2: Timer(s) can be configured for UE to re-acquire GNSS measurement autonomously. Proposal 4: From RAN1 perspective, configured timing for UE to re-acquire GNSS autonomously are timer(s). The configuration of GNSS measurement Timer is up to RAN2.Proposal 5: UE re-acquires GNSS measurement autonomously can start at the point when GNSS validity duration expires and timeAlignmentTimer expires. |
| Ericsson | Observation 4: UE autonomous GNSS measurement is expected to incur less signalling overhead (versus aperiodic GNSS trigger) as it can be configured once at the start of the connection.Observation 5: A UE autonomous GNSS measurement can be tied to the end of the GNSS validity plus extension duration.Observation 6: eNB is expected to use aperiodic GNSS measurement sparingly due to a higher signalling overhead.Proposal 7: A UE autonomous GNSS measurement will occur after a duration D following the end of the GNSS validity duration plus extension duration (if any) when the UE did not receive an aperiodic GNSS measurement trigger during its GNSS validity or GNSS extension duration (if any). FFS: the value of D, e.g., D=0 when UE autonomous measurement is to be performed without delay following the end of GNSS validity plus extension duration.Observation 7: UE autonomous GNSS measurement is a recurring measurement which can cater to periodic scenarios.Observation 8: When the GNSS validity plus extension duration and the GNSS measurement time duration remains unchanged, a UE autonomous GNSS measurement will be a time-periodic GNSS measurement.Observation 9: When the GNSS validity plus extension duration or the GNSS measurement time duration changes, the UE autonomous GNSS measurement instances will adjust accordingly so that it will still be a recurring but not necessarily a time-periodic GNSS measurement occurring at regular time intervals.Proposal 8: RAN1 to conclude that UE autonomous GNSS measurement is a recurring measurement which also supports periodic GNSS measurement when GNSS-related parameters remain unchanged. |

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 for autonomous GNSS measurement***
* Huawei, HiSilicon proposed for autonomous GNSS measurement, the length of GNSS measurement timer for autonomous GNSS re-acquisition is configured by network. If not configured, it equals to the latest reported GNSS position fix time duration for measurement.
* Nokia, NSB proposed to support eNB to broadcast multiple GNSS measurement configurations and UE to report which configuration it applies. Nokia, NSB further proposed the length of the GNSS measurement timer for autonomous GNSS re-acqusition is equal to the length of the network-configured GNSS measurement gap. Nokia, NSB mentioned there may be a need for a GNSS measurement during a long period of downlink/uplink repetitions and RAN1 to discuss handling a GNSS measurement during a long period of downlink/uplink repetitions. In the moderator view, the agreed autonomous GNSS measurement can help solve the issue if GNSS validity duration expires during a long period of downlink/uplink repetitions.
* CATT mentioned If UE is allowed to perform GNSS measurement autonomously, eNB should send the enabling indication to UE and assume the GNSS validity duration as default timer to control UE’s measurement.
* 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, if the timing of autonomously re-acquire GNSS can start at expiry of GNSS validity duration with delay or without delay, then no need for RRC reconfiguration and configured timing mechanism can be supported both eMTC and NB-IoT.
* Lenovo proposed UE can be configured with GNSS measurement gap with periodic way by RRC configuration and Triggering the GNSS measurement for both aperiodic and periodic way should be controlled by network.
* NEC mentioned to support MAC CE design such that it can trigger both aperiodic and periodic GNSS measurements. NEC further proposed the UE may re-acquire GNSS autonomously based on configured timing if it does not receive eNB trigger to make GNSS measurement and support signalling transmission to the gNB to inform about UE triggered GNSS measurement.
* CMCC mentioned For GNSS measurement in RRC connected, GNSS measurement gap can also be configured periodically 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.
* Apple proposed that for timer-based periodic GNSS measurement, GNSS measurement gap and GNSS measurement periodicity are configured via aperiodic GNSS measurement triggering MAC CE.
* Sharp mentioned for autonomous GNSS re-acquisition, the UE may re-acquire GNSS autonomously during GNSS measurement timer, and the length of GNSS measurement timer for autonomous GNSS re-acquisition is configured by network.
* 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.
1. ***start position of the timing of autonomous GNSS measurement***

Huawei, HiSilicon, Nokia, NSB, CATT, CMCC, Sharp, Qualcomm, OPPO, MediaTek, Ericsson preferred the start time of the autonomous GNSS measurement based on the GNSS validity duration.

Nokia, NSB, Xiaomi, Lenovo, NEC, CMCC, Apple, ZTE preferred the start time of the autonomous GNSS measurement based on fixed periodicity value

* 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. UE enters idle mode after autonomous GNSS measurement timer expires.
* Nokia, NSB observed the UE may move in a predictable way, e.g. on a ship or train, and therefore make periodic GNSS measurements useful and proposed to support eNB to configure the UE to make periodic GNSS measurements and autonomous GNSS measurement may be supported as complenary to periodic and aperiodic GNSS measurement. For UE autonomous GNSS measurements, the start time shall be based on the current GNSS validity duration with a network-configured offset.
* CATT mentioned If UE is allowed to perform GNSS measurement autonomously, eNB should send the enabling indication to UE and assume the GNSS validity duration as default timer to control UE’s measurement.
* NEC mentioned to support periodic GNSS measurement to avoid expiry of GNSS validity duration during long UL repetition and to reduce signalling overhead where possible.
* CMCC mentioned For GNSS measurement in RRC connected, GNSS measurement gap can also be configured periodically by network and For autonomous GNSS measurement if UE does not receive eNB triggering to make GNSS measurement, UE can start to re-acquire GNSS position fix when current GNSS validity duration expires, and the time duration for autonomous GNSS measurement is equal to the UE reported GNSS position fix time duration.
* Apple proposed RAN1 considers supporting periodic GNSS measurement timer for UE to re-acquire GNSS position for long connection times as in Fig 1 from R1-2305262, 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.



Figure1: example of periodic GNSS measurement timer

* Sharp mentioned for autonomous GNSS re-acquisition, the UE may re-acquire GNSS autonomously during GNSS measurement timer, the start time of the autonomous GNSS measurement timer is based on GNSS validity duration with a delay and proposed Periodically eNB trigger is not supported.
* Qualcomm mentioned the start time of a UE-autonomous GNSS measurement gap is defined with respect to the end of the GNSS validity duration.
* 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 R1-2305439.



Fig. 2: UE autonomous GNSS re-acquisition procedure

* ZTE mentioned UE may re-acquire GNSS autonomously based on periodic GNSS measurement gap if UE does not receive eNB trigger to make aperiodic GNSS measurement.
* MediaTek observed that On UE autonomously re-acquiring GNSS measurement mechanism, configured timing are flexible duration is better as summarised in table 1 of R1-2305651 and 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 R1-2305651.

***Table 1****: comparisons for the two alternatives for autonomous GNSS re-acquire*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Alt-1: Configured timing are fixed periodicity | Alt-2: Configured timing are flexible duration |  |
| Signalling overhead | High | Low  | Alt-1 needs to configure the periodicity and the duration for UE to do GNSS measurementAlt-2 only needs to configure the duration for UE to do GNSS measurement |
| Flexibility | Low | High | Alt-1 has fixed periodicity, needs to update the periodicity if UE has new GNSS validity duration report (may not work in NB-IoT CP mode)Alt-2 has flexible “periodicity”  |
| Spec impact | High | Low | Alt-1 may need to define procedures for configuring and updatingAlt-2 may need to define procedures for configuring |
| Impact on UE power | More | Less | Alt-1 may require UE to do more GNSS measurement with untimely update of the periodicity |



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

* Ericsson mentioned that UE autonomous GNSS measurement is expected to incur less signalling overhead (versus aperiodic GNSS trigger) as it can be configured once at the start of the connection and A UE autonomous GNSS measurement can be tied to the end of the GNSS validity plus extension duration, eNB is expected to use aperiodic GNSS measurement sparingly due to a higher signalling overhead. Ericsson proposed A UE autonomous GNSS measurement will occur after a duration D following the end of the GNSS validity duration plus extension duration (if any) when the UE did not receive an aperiodic GNSS measurement trigger during its GNSS validity or GNSS extension duration (if any). FFS: the value of D, e.g., D=0 when UE autonomous measurement is to be performed without delay following the end of GNSS validity plus extension duration.

Besides, Ericsson observed UE autonomous GNSS measurement is a recurring measurement which can cater to periodic scenarios, when the GNSS validity plus extension duration and the GNSS measurement time duration remains unchanged, a UE autonomous GNSS measurement will be a time-periodic GNSS measurement and when the GNSS validity plus extension duration or the GNSS measurement time duration changes, the UE autonomous GNSS measurement instances will adjust accordingly so that it will still be a recurring but not necessarily a time-periodic GNSS measurement occurring at regular time intervals. Ericsson proposed RAN1 to conclude that UE autonomous GNSS measurement is a recurring measurement which also supports periodic GNSS measurement when GNSS-related parameters remain unchanged.

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, there are two understandings, one procedure is for flexible “periodicity”, the other procedure is for fixed periodicity. To the moderator understanding, both procedures can work in eMTC NTN, while fixed periodicity may not work in NB-IoT NTN CP mode with no RRC reconfiguration.

## First Round Discussion

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

***F*or autonomous GNSS re-acquisition, the UE may re-acquire GNSS autonomously during GNSS measurement timer where the length of GNSS measurement timer is configured by network**

**Note: the length of GNSS measurement timer is equal to the latest reported GNSS position fix time duration for measurement when the length of GNSS measurement timer is not configured.**

* **FFS: whether the configuration is the same configuration as aperiodically GNSS measurement gap**
* **FFS: start time of the autonomous GNSS measurement timer, e.g. whether the start time is based on GNSS validity duration and/or other fixed value configured by network**

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

***Down select one of alternatives for the start time of the autonomous GNSS measurement timer:***

* **Alt-A:*****For NB-IoT and eMTC, based on the current GNSS validity duration with delay or without delay***
	+ - **FFS: details of delay, e.g. delay can be the duration X where UL transmission can be allowed after original GNSS validity duration expires without GNSS re-acquisition.**
* **Alt-B: *For NB-IoT, based on the current GNSS validity duration with delay or without delay***

**For eMTC, fixed periodicityvalue configured by network**

* + - **FFS: details, e.g. component values for periodicity, signalling for configuration, etc.**
* **Alt-C: For NB-IoT, based on the current GNSS validity duration with delay or without delay**

**For eMTC, fixed periodicityvalue configured by network and/or *based on the current GNSS validity duration with delay or without delay* based on network configuration**

* + - **FFS: details**

Companies are encouraged to provide comments in the table.

|  |  |  |
| --- | --- | --- |
| Companies | Alt A/Alt B/Alt C | Comments |
| Ericsson | Alt-A | 3-1: Support. Start of autonomous timer can be a configurable duration D after the end of GNSS validity duration. E.g. if D is not included in configuration, then D=0 and autonomous timer starts after the end of GNSS validity duration.3-2 Alt-A. Autonomous timer can be started after the end of GNSS validity duration + extension duration (if any) + configurable delay (if any). This already includes the possibility to configure **time-periodic** autonomous gaps. For example, when GNSS validity remains fixed at 10 ms, the autonomous timer will start after every GNSS expiry **periodically** for both eMTC and NB-IoT.  |
| Qualcomm | Alt-A |  |
| Nordic | Alt-A |  |
| ZTE |  | 3-1: It depends on what mechanism is finally used.For periodic measurement gap, we agree that the gap length should be configured. The reason is that eNB will configure periodicity, etc, which already need a configuration signaling. Including a gap length in the configuration signaling will be aligned with aperiodic GNSS measurement gap mechanism and will not have too much impact.While for the case where timer is based on GNSS validity duration, we think the timer length should be directly equal to the reported GNSS position fix time instead of configured by eNB. In our view, when start time of timer is based on GNSS validity duration, it should be exactly the expiration time without delay. Then there is no need define signaling for start time configuration. Moreover, since start time of GNSS measurement timer is out of eNB control, using a unified gap length will not bring any benefit. In this case, specifically define a signaling to indicate the timer length will be costing but not necessary. 3-2: we think fixed periodicity value configured by network can be supported in both NB-IoT and eMTC. If there is concern on a bad periodicity configuration for CP-only NB-IoT due to unchanged RRC configuration, MAC CE based configuration can be used which allows reconfiguration. Or the system may directly use aperiodic eNB trigger mechanism. |
| CMCC |  | Similar view with ZTE, we also think GNSS measurement gap can be configured periodically by network without any triggering signalling.  |
| Spreadtrum | Alt-A |  |
| Huawei, HiSilicon |  | **Initial Proposal 3-1:** support**Initial Proposal 3-2:** at least Alt-A can be supported. It should be clarified that whether the delay can include the remaining time of measurement gap triggered by NW.  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

# [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.

**Agreement (RAN1 112bis):**

UE reports one GNSS position fix time duration for GNSS measurement via a N-bit field at least including [1,2] seconds as component values.

* FFS: value of N, other component value(s) of GNSS position fix time duration (e.g. N=3, with value in [3,7,13,19,25, X] seconds, and X is FFS).

FFS: whether RAN4 input is needed.

**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.

**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

**RAN2-121bis**

Working Assumption:

1. GNSS validity duration UE reported after GNSS measurement is the remaining validity duration

## Company contribution views

|  |  |
| --- | --- |
| Contribution | Observation/Proposals |
| Huawei, HiSilicon | Proposal 3: Add the component values [3,4,5,6,7,13,19,25] for GNSS position fix time duration reported by UE.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 9: 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 12: RAN1 to discuss UE reporting GNSS position fix time duration if the duration has changed since the previous report.Observation 10: The UE’s mobility state/location may change and therefore cause a change in the expected GNSS validity duration.Observation 11: GNSS reacquisition may not always be needed if the UE has been RRC Idle for a short period during a long connection.Proposal 13: 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.Observation 12: UE is most likely in hot GNSS state during a long RRC ConnectionObservation 13: the “infinity” value is not needed for the GNSS position fix time duration, because it is already defined for the GNSS validity durationProposal 14: RAN1 to ask for RAN4 input on the number of GNSS position fix time duration values and the actual values. |
| CATT | Proposal 5: GNSS position fix time duration for GNSS measurement can be configured with 3-bit signaling. |
| 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. |
| Lenovo | Proposal 5: UE is not expected to further update the GNSS position fix time duration in connected. |
| Sharp | Proposal 3: UE reports one GNSS position fix time duration for GNSS measurement via a 3-bit field, indicating the index in the set of [1,2,3,7,13,19,25,X] seconds. |
| 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.)
 |
| MediaTek | Proposal 3: 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. |
| Nordic Semiconductor ASA | Proposal 2: Due to large variation of the measurement time required to obtain a new position fix, a large enough set of values should be specified for the GNSS fix time duration. |
| Ericsson | Proposal 18: 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 19: UE reports only one value (from the set of possible values) for the GNSS measurement time duration in RRC connected state. |

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}, with GNSS validity duration UE reported after GNSS measurement is the remaining validity duration.

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

* Huawei, HiSilicon mentioned the component values [3,4,5,6,7,13,19,25] for GNSS position fix time duration reported by UE
* Nokia, NSB mentioned the UE may move and/or the propagation conditions may change and therefore cause a change in the required GNSS position fix time duration and RAN1 to discuss UE reporting GNSS position fix time duration if the duration has changed since the previous report. Nokia, NSB observed UE is most likely in hot GNSS state during a long RRC Connection and the “infinity” value is not needed for the GNSS position fix time duration, because it is already defined for the GNSS validity duration. Nokia, NSB proposed RAN1 to ask for RAN4 input on the number of GNSS position fix time duration values and the actual values. To the moderator understanding, RAN2-116bis has agreed 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. Hence, for GNSS measurement in RRC connected, both hot and warm start can be considered.
* CATT mentioned GNSS position fix time duration for GNSS measurement can be configured with 3-bit signaling.
* InterDigital mentioned 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).
* Lenovo mentioned UE is not expected to further update the GNSS position fix time duration in connected.
* Sharp mentioned UE reports one GNSS position fix time duration for GNSS measurement via a 3-bit field, indicating the index in the set of [1,2,3,7,13,19,25,X] seconds.
* 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

* Nordic Semiconductor ASA mentioned Due to large variation of the measurement time required to obtain a new position fix, a large enough set of values should be specified for the GNSS fix time duration.
* 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.
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, in RAN2-121bis, there was working assumption that GNSS validity duration UE reported after GNSS measurement is the remaining validity 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. To the moderator understanding, RAN2 has mad working assumption that UE reported after GNSS measurement is the remaining validity duration, it should be UE implementation on how to calculate the GNSS validity duration.
* 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 UE report the remaining GNSS validity duration in Msg5 and in RAN2-121bis, there is working assumption that GNSS validity duration UE reported after GNSS measurement is the remaining validity duration.
* 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.
* 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, RAN1 can further discuss whether UE needs to report GNSS position fix time duration for GNSS measurement in RRC connected state. Considering contributed companies’ proposals, it seems reasonable where UE to report its GNSS position fix time duration using a 4-bit field with the following component values: {1,2,3,4,5,6,7,13,19,25,37} seconds. 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} and report remaining validity duration.

## First Round Discussion

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

***UE reports one GNSS position fix time duration for GNSS measurement via a 4-bit field with component values [1,2,3,4,5,6,7,13,19,25,37]***

* ***FFS: other component values***

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

***Support UE to*** ***report GNSS position fix time duration for GNSS measurement in RRC connected state.***

Companies are encouraged to provide comments within the following table:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson | 4-1: A 3-bit value should suffice: ***[1,2,3,~~4,5,6~~,7,13,19,25,37].*** Why is 37 sec in the list instead of 31 sec (a GPS frame can be 30 sec so 31 sec seems more logical?) Plus, will this GPS-based range work for other GNSS systems? 4-2: OK to have the functionality but it is expected to be a rare event as UE’s GNSS position fix time is expected to remain unchanged during a connection. |
| Nordic | We are fine with both proposals |
| ZTE | 4-2: Not support. GNSS position fix time duration is a stable chip capability. There is no need to update it in RRC connected state. If the channel condition is poor, the impact is that the UE will failed to obtain a GNSS position in the fixed time instead of costing longer time to obtain a position.  |
| CMCC | For Initial Proposal 4-2: From our perspective, the GNSS position fix time duration indicates the UE capability to finish a GNSS measurement, which may not change dynamically for each GNSS measurement during the connected state. |
| Spreadtrum | For Initial Proposal 4-2, we share the similar views with ZTE. |
| Huawei, HiSilicon | **Initial Proposal 4-1:** Support. To our understanding, the report is higher layer signalling and overhead is relative insensitive. More granularity for hot start mode can facilitate different types of GNSS module installed in a UE.**Initial Proposal 4-2:** maybe we should first clarify the previous agreement on the configuration of measurement gap. If it is based on RRC signalling, maybe such report is not necessary as the gap may not be changed. if the configuration is from the triggering MAC CE, we think the mechanism in 4-2 provide UE flexibility when the start mode changes.  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# [Active] Issue #5: 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

**RAN2-121bis**

UE can stay in RRC\_CONNECTED state when current GNSS position becomes out-of-date if the UE enters a GNSS measurement gap. FFS whether the new GNSS

## 5.1 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. |
| 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: UE shall move to RRC Idle if the GNSS measurement fails. The GNSS measurement shall be started before or at the GNSS validity duration expiry.Observation 14: the eNB may trigger an “early” GNSS measurement gap, before expiry of the current GNSS validity duration, if the UE starts moving because it would cause the current GNSS position to become outdated.Proposal 15: the eNB can trigger a GNSS measurement gap, which can end before the current GNSS validity duration expiresProposal 16: If the UE failed to reacquire the GNSS position fix in an early network-triggered GNSS measurement gap, the UE is not allowed to transmit after the GNSS measurement gap even if the the current GNSS validity duration has not expired.Proposal 17: The UE shall indicate success of the GNSS measurement by reporting the new remaining GNSS validity duration.Proposal 18: 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 15: 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.Proposal 19: RAN1 to discuss whether the UE after a successful GNSS measurement gap either performs the Random Access procedure or reuses/resets the previous N\_TA. |
| CATT | Observation 1: UE is not necessary to report the new GNSS validity duration if it is same as old GNSS validity duration. Observation 2: Early GNSS measurement before its expiry makes UE waste its power consumption.Proposal 1: It is not recommended to enforce UE to conduct GNSS measurement before its position expiry. Proposal 2: UE should send UL PRACH signal to indicate network when the GNSS measurement is successful. |
| InterDigital | Proposal 5: Alt-1 is adopted to inform eNB the success of GNSS measurement at UE side after GNSS measurement in RRC connected.Proposal 6: ‘1’ bit indication is introduced to indicate success of GNSS measurement and new GNSS validity duration is provided only when the value is different from the previously reported value.Proposal 7: If a UE fails to acquire GNSS position fix within the measurement gap, the UE falls into Idle mode after the current GNSS validity duration expires. |
| Lenovo | Proposal 4: 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. |
| Xiaomi | Proposal 4: UE reports the new GNSS validity duration after the successful GNSS measurement. |
| CMCC | Observation 1. The GNSS measurement time duration may not change dynamically for each GNSS measurement during the connected state.Observation 2. If UE only reports new GNSS validity duration when it changes after GNSS measurement, additional indication (implicit by UL transmission or explicit indication) is needed to indicate the success of GNSS measurement when GNSS validity is not changed.Proposal 5. The UE can report the new GNSS validity duration after each GNSS measurement, which can also implicitly indicate that UE successfully re-acquires new GNSS position fix.Proposal 6. If UE can not re-acquire the new GNSS position fix successfully until the GNSS validity duration expires and can not autonomously re-acquire the GNSS when configured by the network, the UE goes to IDLE mode. |
| Apple | Proposal 4: eNB notices the success of GNSS measurement at UE side via the reception of any UL transmission from the UE. |
| Sharp | Proposal 4: UE goes to IDLE mode if UE failed to re-acquire GNSS position fix after configured timing/timer for autonomous GNSS reacquisition and after current GNSS validity duration expired in RRC\_CONNECTED mode. |
| Qualcomm | Proposal 5: 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.
 |
| OPPO | Proposal 5: UE goes to idle if the GNSS acquisition fails within the measurement gap.Proposal 6: UE needs to perform RACH procedure after accomplishing the GNSS measurement to inform the eNB that the measurement is accomplished. |
| ZTE | Proposal 4: UE should report the new GNSS validity duration every time after accomplishing the GNSS measurement.Proposal 5: UE report of new GNSS validity duration can be used to implicitly indicate the success of GNSS measurement.Proposal 6: Report of new GNSS validity duration, i.e., implicit success indication of GNSS measurement, should be transmitted within a time window after GNSS measurement. The GNSS measurement is thought failed if no new GNSS validity duration report by the end of the time window. The time window starts at the end of GNSS measurement gap. The time window length is configured by network. |
| MediaTek | Observation 3: If UE re-acquires GNSS position fix successfully after GNSS validity duration expires 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: If UE re-acquires GNSS position fix successfully after GNSS validity duration expires 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. |
| Nordic Semiconductor ASA | Proposal 4: 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.Observation 1: From the eNB point of view, it would be highly desirable that there is a configured measurement fallback period after the GNSS measurement gap, i.e., a window of the configured length Y during which the eNB tries to transmit a UL grant for the UE. The network can stop scheduling of the UE if the UE is not able to respond to the UL grant, due to the GNSS measurement failure.Proposal 5: There should be a configurable measurement fallback period after the GNSS measurement gap, i.e., a window of the configured length Y during which the eNB tries to transmit a UL grant for the UE. |
| Ericsson | Proposal 16: A UE in connected mode shall always report its GNSS validity duration after GNSS reacquisition.Proposal 17: If the eNB receives the GNSS validity duration from the UE, it concludes that the UE’s latest GNSS measurement was successful. |

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 last meeting, the following FL recommendation has been made:

|  |
| --- |
| ***FL recommendation 6-1:******Companies are encouraged to evaluate on*** * 1. ***whether the GNSS measurement gap can end before current GNSS validity duration expires***
	2. ***in case UE failed to re-acquire GNSS position fix before current GNSS validity duration expires, whether UL transmission is allowed before current GNSS validity duration expires***
	3. ***how to inform eNB the success of GNSS measurement at UE side after GNSS measurement in RRC connected and down select:***
	+ ***Alt-1: After current GNSS validity duration expires, the reception of any UL transmission from the UE at eNB after the GNSS measurement***
		- ***FFS: whether/how to indicate success before current GNSS validity duration expires***
		- ***Note: In Alt-1, UE doesn’t report the new GNSS validity duration every time after accomplishing the GNSS measurement.***
* ***Alt-2: UE should report the new GNSS validity duration every time after accomplishing the GNSS measurement***
 |

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 success indication of GNSS measurement before and after current GNSS validity duration expires

Huawei, HiSilicon, CATT, Lenovo, Apple, OPPO, MediaTek, Nordic Semiconductor ASA preferred Alt-1: After current GNSS validity duration expires, the reception of any UL transmission from the UE at eNB after the GNSS measurement

Nokia, NSB, InterDigital, Xiaomi, CMCC, ZTE, Ericsson preferred Alt-2: UE should report the new GNSS validity duration every time after accomplishing the GNSS measurement

* 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. UE can update the validity duration in the MAC CE of the NPUSCH If GNSS validity duration is changed since the last measurement.
* Nokia, NSB proposed the UE shall indicate success of the GNSS measurement by reporting the new remaining GNSS validity duration 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. Nokia, NSB observed 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 and proposed RAN1 to discuss whether the UE after a successful GNSS measurement gap either performs the Random Access procedure or reuses/resets the previous N\_TA.
* CATT observed UE is not necessary to report the new GNSS validity duration if it is same as old GNSS validity duration and early GNSS measurement before its expiry makes UE waste its power consumption. CATT further proposed It is not recommended to enforce UE to conduct GNSS measurement before its position expiry and UE should send UL PRACH signal to indicate network when the GNSS measurement is successful.
* InterDigital mentioned Alt-1 The UE will report the new GNSS validity duration is adopted to inform eNB the success of GNSS measurement at UE side after GNSS measurement in RRC connected. InterDigital further proposed ‘1’ bit indication is introduced to indicate success of GNSS measurement, and new GNSS validity duration is provided only when the value is different from the previously reported value.
* 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.
* Xiaomi commented the UE may perform the GNSS measurement either before or after the end of the last GNSS validity duration, it is possible that even the UE fails the GNSS measurement, the UE can still have a valid GNSS position, and then the UL transmissions should be allowed after the GNSS measurement and proposed UE reports the new GNSS validity duration after the successful GNSS measurement.
* CMCC Observed the GNSS measurement time duration may not change dynamically for each GNSS measurement during the connected state and if UE only reports new GNSS validity duration when it changes after GNSS measurement, additional indication (implicit by UL transmission or explicit indication) is needed to indicate the success of GNSS measurement when GNSS validity is not changed. CMCC proposed the UE can report the new GNSS validity duration after each GNSS measurement, which can also implicitly indicate that UE successfully re-acquires new GNSS position fix.
* Apple proposed eNB notices the success of GNSS measurement at UE side via the reception of any UL transmission from the UE.
* OPPO proposed UE needs to perform RACH procedure after accomplishing the GNSS measurement to inform the eNB that the measurement is accomplished.
* ZTE mentioned UE should report the new GNSS validity duration every time after accomplishing the GNSS measurement and UE report of new GNSS validity duration can be used to implicitly indicate the success of GNSS measurement. ZTE further proposed that Report of new GNSS validity duration, i.e., implicit success indication of GNSS measurement, should be transmitted within a time window after GNSS measurement. The GNSS measurement is thought failed if no new GNSS validity duration report by the end of the time window with The time window starts at the end of GNSS measurement gap and the time window length is configured by network. To the moderator understanding, report new remaining GNSS validity duration can be scheduled by network or UE sends SR.
* MediaTek mentioned If UE re-acquires GNSS position fix successfully after GNSS validity duration expires in RRC connected, successful GNSS measurement is implicitly known in the following UL transmission.
* 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. Nordic Semiconductor ASA observed From the eNB point of view, it would be highly desirable that there is a configured measurement fallback period after the GNSS measurement gap, i.e., a window of the configured length Y during which the eNB tries to transmit a UL grant for the UE. The network can stop scheduling of the UE if the UE is not able to respond to the UL grant, due to the GNSS measurement failure and proposed there should be a configurable measurement fallback period after the GNSS measurement gap, i.e., a window of the configured length Y during which the eNB tries to transmit a UL grant for the UE. To the moderator understanding, report new remaining GNSS validity duration can be scheduled by network or UE sends SR.
* 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
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.
* Nokia, NSB mentioned the common understanding between UE and eNB on when the UE is performing GNSS measurements, and is unavailable for scheduling, is of key importance and proposed UE shall move to RRC Idle if the GNSS measurement fails. The GNSS measurement shall be started before or at the GNSS validity duration expiry. Nokia, NSB proposed the eNB can trigger a GNSS measurement gap, which can end before the current GNSS validity duration expires and If the UE failed to reacquire the GNSS position fix in an early network-triggered GNSS measurement gap, the UE is not allowed to transmit after the GNSS measurement gap even if the the current GNSS validity duration has not expired.
* InterDigital mentioned if a UE fails to acquire GNSS position fix within the measurement gap, the UE falls into Idle mode after the current GNSS validity duration expires.
* CMCC mentioned If UE can not re-acquire the new GNSS position fix successfully until the GNSS validity duration expires and can not autonomously re-acquire the GNSS when configured by the network, the UE goes to IDLE mode.
* 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.
* OPPO mentioned UE goes to idle if the GNSS acquisition fails within the measurement gap.

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

* CMCC mentioned If UE can not re-acquire the new GNSS position fix successfully until the GNSS validity duration expires and can not autonomously re-acquire the GNSS when configured by the network, the UE goes to IDLE mode.
* Sharp mentioned UE goes to IDLE mode if UE failed to re-acquire GNSS position fix after configured timing/timer for autonomous GNSS reacquisition and after current GNSS validity duration expired in RRC\_CONNECTED mode.
* 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 on 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. On failure of GNSS measurement, the agreement in Rel-17 that RAN2 made, when the GNSS fix becomes outdated in RRC\_CONNECTED mode, the UE goes to IDLE mode should be considered for Rel-18. And RAN1 can further discuss in case UE failed to re-acquire GNSS position fix before current GNSS validity duration expires, whether UL transmission is allowed before current GNSS validity duration expires.

## 5.2 First Round Discussion

***Initial Proposal 5-1:***

***Companies are encouraged to comment on, in case UE failed to re-acquire GNSS position fix before current GNSS validity duration expires, whether UL transmission is allowed before current GNSS validity duration expires.***

***Initial Proposal 5-2:***

***For GNSS measurement finished after current GNSS validity duration expires, the reception of any UL transmission from the UE at eNB after the GNSS measurement can be utilized to inform eNB the success of GNSS measurement in RRC connected.***

* ***Note: UE may report the new remining GNSS validity duration in the UL transmission.***
* ***FFS: whether/how to indicate success for GNSS measurement finished before current GNSS validity duration expires (e.g. UE should report the new remaining GNSS validity duration to indicate success)***

***Initial Proposal 5-3:***

**After current GNSS validity duration expired, UE goes to IDLE mode if UE failed to re-acquire GNSS position fix after configured timing for autonomous GNSS reacquisition and/or after aperiodically GNSS measurement gap.**

Companies are encouraged to provide comments within the following table:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson | 5-1: We think that UL sync can be allowed if TAT has not expired.5-2: Not support. We think that a UE should ALWAYS report its GNSS validity duration after a GNSS position fix. 5-3: Support. |
| Qualcomm | 5-1: If the validity duration is still valid, then the UE can keep the connection as if the GNSS failure had not happened.5-2: Although this may be true in most cases, the general framework should be that the UE sends the new validity duration and this is the implicit indication to the eNB that the reacquisition was successful.5-3: In general we are OK with this, but this is up to RAN2 to decide and captured in RAN2 specifications (e.g. RAN2 may decide to go through RLF instead of IDLE). |
| Nordic | 5-1: UE should not transmit anything, if GNSS measurement fails5-2: We agree with Qualcomm5-3: In general we are Ok, but the exact procedure depends on the agreed method for UE to report the success of the measurement |
| ZTE | 5-1: We think UL transmission is not allowed after failed GNSS position fix. For GNSS measurement gap, it is not correct implementation to trigger a gap before the expiration time of current GNSS validity duration, since it only wastes the GNSS validity duration and causes higher signaling overhead. Therefore, when eNB trigger a GNSS position fix, it means that eNB assumes the current GNSS is no longer valid and the corresponding information such as validity duration should not be kept. Therefore, UE should go IDLE and no UL transmission allowed in case UE failed to re-acquire GNSS position fix no matter whether current GNSS validity duration expires.5-2: OK.5-2b: Besides which signaling to indicate the success, we want to prompt the discussion on when to indicate the success. It is worth noting that no matter which alternative is finally supported, the UL transmission is triggered by UE. That means, when to indicate the success to eNB is up to UE implementation and no constraint on the delay between measurement gap and first UL transmission till now. Obviously, eNB cannot wait forever for UE indication of success. Generally, eNB will think UE lost sync and release the connection if it does not receive the success indication for a period of time. If UE report the success after the eNB waiting time, there will be misalignment between UE and gNB. Therefore, in order to achieve consensus between UE and gNB, UE should indicate the success within certain restriction, e.g., a time window configured by eNB after GNSS measurement gap.5-3: We think UE should go IDLE if it failed to reacquire GNSS position fix, no matter current GNSS validity duration expired or not. |
| CMCC | 5-1: We think UL transmission is not allowed if UE fails to re-acquire GNSS position fix within the GNSS measurement gap. 5-2: We also think it is a straightforward way that UE can report the new GNSS validity duration after each GNSS measurement, which can also implicitly indicate that UE successfully re-acquires new GNSS position fix.5-3: We are generally fine with the proposal. |
| Huawei, HiSilicon | **Initial Proposal 5-1:** UE can still be in CONNECTED state but the UL transmission should not be allowed considering the potential interference due to inaccurate GNSS information. UE can be triggered with another measurement, or perform autonomous GNSS position fix if the condition to start the autonomous GNSS measurement timer is satisfied.**Initial Proposal 5-2:** seems no need to differentiate the design depending on whether GNSS validity duration expires. The first UL transmission after the measurement can be used to indicate the success of GNSS measurement. The new validity duration can be carried in this UL if it is different from last report.**Initial Proposal 5-3:** the “**after aperiodically GNSS measurement gap.**” is not necessary. after GNSS validity duration expires, NW will not trigger measurement gap. We are fine the FL proposal without part after “and/or…”  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# 6 [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 6.1, 6.2, 6.3, 6.4.

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

#### 6.1.1 Company contributing views

|  |  |
| --- | --- |
| 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.

#### 6.1.2 First Round Discussion

***FL recommendation 6.1:***

***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:

|  |  |
| --- | --- |
| Companies | Comments |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 6.2 UE requests eNB to trigger GNSS measurement

#### 6.2.1 Company contributing views

|  |  |
| --- | --- |
| Contribution | Observation/Proposals |
| Spreadtrum | Proposal 2: UE can send a request for network to trigger GNSS measurement aperiodically. |
| Nokia, NSB | Observation 4: 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 5: 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 9: Support the UE to request eNB to trigger at least an aperiodic GNSS measurement. |
| Samsung | Proposal 2: Specify the condition of UE triggered GNSS measurement, e.g., when GNSS validity timer is expired, there are UL data to transmit, and/or the UL synchronization is lost. |

Spreadtrum proposed UE can send a request for network to trigger GNSS measurement aperiodically.

Nokia, NSB observed that 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, NSB further 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., when GNSS validity timer is expired, there are UL data to transmit, and/or the UL synchronization is lost.

Moderator View: On UE request eNB to trigger GNSS measurement, majority companies mentioned in past few meetings that autonomously GNSS measurement and aperiodically GNSS measurement gap is enough. To the moderator view, 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.

#### 6.2.2 First Round Discussion

***FL recommendation 6.2:***

***Proponents for UE requests eNB to trigger GNSS measurement are encouraged to further discuss offline to get more support.***

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

|  |  |
| --- | --- |
| Companies | Comments |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 6.3 PDCCH order/DCI-based GNSS measurement trigger

#### 6.3.1 Company contributing views

|  |  |
| --- | --- |
| 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).

#### 6.3.2 First Round Discussion

***FL recommendation 6.3:***

***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:

|  |  |
| --- | --- |
| Companies | Comments |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## 6.4 Skip GNSS measurement trigger

**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

#### 6.4.1 Company contributing views

|  |  |
| --- | --- |
| Contribution | Observation/Proposals |
| Qualcomm | Proposal 4: 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.•The UE reports the remaining validity duration after skipping the GNSS reacquisition. |

Qualcomm mentioned if the GNSS trigger is received long before the expiration of the validity timer (e.g. in case a previous validity duration report was lost), the UE should be allowed to skip the GNSS reacquisition and report the current validity duration. Qualcomm further proposed 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 and the UE reports the remaining validity duration after skipping the GNSS reacquisition.

Moderator View: RAN1 has agreed that for eNB aperiodically triggers UE to make GNSS measurement, a MAC CE is used. To the moderator understanding, the aperiodically triggered GNSS measurement gap should only be triggered by eNB when there does have a need for UE to do GNSS measurement.

#### 6.4.2 First Round Discussion

***FL recommendation 6.4:***

***Companies are encouraged to comment to align understanding on whether*** ***UE should be allowed to skip the GNSS reacquisition aperiodically triggered by network when the remaining GNSS validity duration is larger than some duration.***

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

|  |  |
| --- | --- |
| Companies | Comments |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# 7 Proposals for online/offline discussions

# 8 Conclusion

# 9 References

1. RP-223519, Moderator (MediaTek), Revised WID on IoT NTN enhancements, 12-16 December, 2022
2. R1-2304575, Discussion on improved GNSS operations for IoT NTN, Spreadtrum Communications
3. R1-2304635, Discussion on improved GNSS operations for IoT NTN, Huawei, HiSilicon
4. R1-2304688, Enhancements for long connections in NB-IoT/eMTC over NTN, Nokia, Nokia Shanghai Bell
5. R1-2304754, Discussion on remaining issues of improved GNSS operations for IoT NTN, CATT
6. R1-2304782, Improved GNSS operations for IoT NTN, InterDigital, Inc.
7. R1-2304852, Improved GNSS operations for IoT NTN, Lenovo
8. R1-2304919, Discussion on the improved GNSS operation for IoT NTN, xiaomi
9. R1-2305069, On Improved GNSS Operations for IoT NTN, NEC
10. R1-2305111, Discussion on improved GNSS operations for IoT NTN, CMCC
11. R1-2305262, On improved GNSS operations for IoT NTN, Apple
12. R1-2305286, Remaining issues on improved GNSS operations for IoT NTN, Sharp
13. R1-2305355, Improved GNSS Operations for IoT-NTN, Qualcomm Incorporated
14. R1-2305439, Discussion on improved GNSS operations for IoT NTN, OPPO
15. R1-2305532, Improved GNSS operations for IoT NTN, Samsung
16. R1-2305559, Discussion on improved GNSS operation for IoT-NTN, ZTE
17. R1-2305651, Improved GNSS operations for IoT NTN, MediaTek Inc.
18. R1-2305910, Improved GNSS operation for IoT NTN, Nordic Semiconductor ASA
19. R1-2305916, On Improved GNSS operation in IoT NTN, Ericsson