3GPP TSG-RAN WG2 #112e Tdoc R2-2111342

Electronic meeting, November 2nd – 13th 2020

Agenda Item: 8.10.3.1

Source: Ericsson

Title: [offline-108] Extended NAS timers (Ericsson)

Document for: Discussion

# 1 Introduction

RAN2 discussed received LS from CT1 based on documents [7][8][9] and concluded to have offline on the issues:

* [AT116-e][108][NRN] Extended NAS timers (Ericsson)

Initial scope: continue the discussion on extended NAS timers and attempt a reply LS

Initial intended outcome: Summary of the offline discussion and draft reply LS.

Initial deadline (for companies' feedback): Tuesday 2021-11-09 1000 UTC

Initial deadline (for rapporteur's summary in R2-2111342): Tuesday 2021-11-09 1600 UTC

R2-2111342 [offline-108] Extended NAS timers Ericsson discussion Rel-17 NR\_NTN\_solutions-Core

# 2 LS from CT1

An LS [1] was first received in RAN2#112-e where CT1 asked for guidance on a set of RAN timers and the reply was sent in [2]. For RAN2#116-e another LS asking guidance on the design of NAS supervision timers was received in [3].

RAN2 received an LS from CT1 asking about feasibility of the current NAS supervision timer [2].

*In the SA2 study on 5GSat it was concluded for KI#3 (Delay in satellite) that NAS supervision timers need to be extended to handle the additional delay added at satellite access compared to existing NG-RAN. It was also captured in the study that final determination of extended timer values is left for stage 3. In the analysis of NAS timer extension at satellite access, CT1 would need additional information from RAN2 to determine possible updates to normative stage 3 specification.*

*As the NAS supervision timers control triggering of NAS message re-transmission and determination of NAS procedure failure, updated timing for NAS message transport in AS compared to current NG-RAN needs to be considered. Therefore, CT1 would appreciate answers to the following questions:*

* *For all satellite access types (LEO, MEO, GEO) where AS timing is updated, what is the worst-case delay in AS for transport of NAS messages via satellite access, including potential delays due to GNSS fix acquisition:*
	+ 1. *For initial NAS messages in the UL direction;*
		2. *For non-initial NAS messages in the UL direction; and*
		3. *For NAS messages in the DL direction.*

***ACTION:*** *CT1 asks RAN2 to provide answers to the questions above, and any other feedback seen useful for CT1 on the topic of extended NAS supervision timers at satellite access.*

# 2 Discussion

Unlike timer values like T300 and T312 that have configurable values in the RRC specification, the NAS supervision timers have fixed values in specification. The NAS supervision timers basically tell for how long NAS waits until determining that there was a failure, e.g. the request or response message was lost, and a re-transmission of the request may be attempted. This supervision period includes the time AS transports the NAS message between NAS in the UE and NGAP in the network, including any retransmissions. Current value for NR is typically 15 s for initial NAS messages such as Registration Request and Service Request, which are similar to the corresponding timers in an LTE network. The extension of these timer values has been studied and extended in the context of coverage extension and NB-IoT. The related AS timers T300 and T312 may have longer values supported than what is feasible from the NAS supervision timer perspective.

CT1 is asking RAN2 input on three timing related aspects. Namely, CT1 would like feedback on worse case delay in AS for each LEO, MEO, GEO for

* For initial NAS messages in the UL direction;
* For non-initial NAS messages in the UL direction; and
* For NAS messages in the DL direction.

including potential delays due to GNSS fix acquisition:

The LS is received under WI code 5GSAT\_ARCH-CT and it was discussed in online whether the response should be only for NR WI perspective or also on IoT WI perspective. In case both WI perspective, RAN2 needs to figure out how it is able to arrange agreement/conclusion from both WI perspective.

**Question 1 Do companies prefer to respond on NR WI behalf or both NR and IoT NTN WI behalf? Note that if both we need views how it is done and how it is coordinated with IoT NTN.**

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| **Company** | **NR WI only** | **NR and IoT WI** | **If both Wis, how it is organized?** |
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## 2.1 Round trip times in NTN

When the UE performs random access or initial attach it will take a number of roundtrips and a higher number of round trips if there are failures at any point in the random access procedures or attach procedures. The long round trip time may thus be a driving factor for the time for the procedures and by extension the time that it takes to complete the procedures that the NAS and AS timers are controlling. The propagation round trip times are shown in the following table [4]:

Table 4.2-2: Reference scenario parameters

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| --- | --- | --- |
| Scenarios | GEO based non-terrestrial access network (Scenario A and B) | LEO based non-terrestrial access network (Scenario C & D) |
| . . . |
| Max Round Trip Delay (propagation delay only) | Scenario A: 541.46 ms (service and feeder links)Scenario B: 270.73 ms (service link only) | Scenario C: (transparent payload: service and feeder links)* 25.77 ms (600km)
* 41.77 ms (1200km)

Scenario D: (regenerative payload: service link only)* 12.89 ms (600km)
* 20.89 ms (1200km)
 |
| Max differential delay within a cell (Note 6) | 10.3 ms | 3.12 ms and 3.18 ms for respectively 600km and 1200km |
| Max Doppler shift (earth fixed user equipment) | 0.93 ppm | 24 ppm (600km)21ppm(1200km)  |
| . . . |

Also note that delays in MEO are much harder to estimate as MEO satellite altitude ranges from around 2000 km to <35768 km (sub-GEO). Propagation delays for MEO are anywhere between LEO and GEO.

**Question 2 Do companies agree to use the RTT values shown in table above(4.2-2) for LEO and MEO?**

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| **Company** | **Yes/no** | **Comments** |
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**Question 3 Do companies agree to state that MEO delay may be anything in between what is stated for LEO&GEO and provide values only for LEO&GEO?**

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| **Company** | **Yes/no** | **Comments** |
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## 2.2 NAS message delay without GNSS impact

## 2.2.1 Initial NAS message in uplink delay

Here we analyse Initial NAS message in uplink delay without GNSS impact. GNSS impact is treated separately later.



Figure 1. Delays due to UE needing to perform random access to send the UL NAS message.

For initial uplink delay, the UE would have to perform random access. This means that the UE should perform random access (msg1-msg4) and then transmit the initial NAS message in msg5 and then receive a response. The full procedure along with the time due to random access retries can be seen in Figure 2.

By not considering the delays such as to acquire system information or perform cell selection and reselection, the potential delays due to the above and with different amount of attempts can be calculated as:

$$T\_{initial\_{access}}=T\_{message\_{initial\_{access}}}=$$

$$\left(N\_{initial access exchanges}+N\_{retransmission factor}\right)\*RTT$$

where the $N\_{initial access exchanges}$ is equal to 2.5, which represents the number of message exchanges in case all messages are correctly received and the $N\_{retransmission factor}$ is when a message fails and need to be retransmitted and it takes on the values {*0, 0.5, 1, 1.5, …*} depending on which message that fails and how many failures there are during the procedures. For random access we will consider a larger amount of needed retransmissions due to a range of uncertainties that is not as likely to be there when the UE is connected mode as in Section 2.2.2.

**Question 4 Do companies agree with formula provided above for calculating the delay for initial NAS message in uplink without GNSS impact?**

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| **Company** | **Yes/no** | **Comments** |
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The number of retransmissions during random access is hard to quantify; for instance, the maximum number of configurable msg1 attempts is 200, but we would doubt that this would be a reasonable configuration for NTN. In this case, we put an arbitrary number as the maximum number of retransmission attempts during random access. This can be seen in Table 1 for a number of different cases.

Table 1

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| --- | --- | --- |
|  | $$N\_{retransmission factor}$$ | **Delays** |
| LEO (600 km)RTT = 26 ms | 0 | $RTT×2.5=0.07 s$  |
| 4 | $$RTT×6.5=0.17 s$$ |
| 8 | $$RTT×10.5=0.27 s$$ |
| 16 | $$RTT×18.5=0.481 s$$ |
| MEO (3500 km)RTT = 60 ms | 0 | $$RTT×2.5=0.15 s$$ |
| 4 | $$RTT×6.5=0.39 s$$ |
| 8 | $$RTT×10.5=0.63 s$$ |
| 16 | $$RTT×18.5=1.11 s$$ |
| GEO (35768 km)RTT = 542 ms | 0 | $$RTT×2.5=1.636 s$$ |
| 4 | $$RTT×6.5=3.52 s$$ |
| 8 | $$RTT × 10.5=5.69 s$$ |
| 16 | $$RTT × 18.5=10.02 s$$ |

**Question 5 Do companies agree with the values provided in Table 1? If another retransmission factor is preferred, please provide the calculated value together with the preferred retransmission factor.**

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| **Company** | **Yes/no** | **Comments** |
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## 2.2.3 Non-initial NAS message in uplink direction

Here we analyse Non-initial NAS message in uplink delay without GNSS impact. GNSS impact is treated separately later.



Figure 2. Delays due to SR-BSR procedures.

Non-initial NAS messages are sent via SRB1 on high-priority bearers. Worst case without re-transmissions is if the UE does not have any uplink resources and has to go through the SR-BSR procedures. By not considering scheduling delays and modelling the retransmissions we get the following delay for delivering a non-initial NAS message in the UL direction.

$$T\_{non-initial access}=\left(N\_{SR-BSR}+0.5+N\_{retransmission factor}\right)\*RTT$$

where the $N\_{SR-BSR}=2$, and the $N\_{retransmission factor}$ models the number of retransmissions due to failures in the uplink PUSCH transmissions or in the SR-BSR procedure.

**Question 6 Do companies agree with formula provided above for calculating the delay for non-initial NAS message in uplink without GNSS impact?**

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For the retransmission factor we consider a small amount of retransmissions.

Table 2

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|  | $$N\_{retransmission factor}$$ | **Delay** |
| LEO (600 km)RTT = 26 ms | 0 | $RTT×2.5≈0.07 s$  |
| 2 | $$RTT×4.5≈0.12 s$$ |
| 4 | $$RTT×6.5≈0.17 s$$ |
| MEO (3500 km)RTT = 60 ms | 0 | $$RTT×2.5≈0.15 s$$ |
| 2 | $$RTT×4.5≈0.27 s$$ |
| 4 | $$RTT×6.5=0.39 s$$ |
| GEO (35768 km)RTT = 542 ms | 0 | $$RTT×2.5=1.36 s$$ |
| 2 | $$RTT×4.5=2.44 s$$ |
| 4 | $$RTT×6.5=3.52 s$$ |

**Question 7 Do companies agree with the values provided in Table 2? If another retransmission factor is preferred, please provide the calculated value together with the preferred retransmission factor.**

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## 2.2.3 NAS messages in the downlink direction

NAS messages in the downlink direction are sent via SRB1 on high-priority bearers similar to the uplink case. In this case the UE would be in connected mode, the network would control the resources, and the amount of round-trips needs should be smaller compared to the other case. Worst case delay without re-transmissions is simply the one-way transmission delay. We can model this through the following:

$$T\_{non-initial downlink}=\left(0.5+N\_{retransmission factor}\right)\*RTT$$

and the $N\_{retransmission factor}$ models the number of retransmissions due to failures in the PDSCH transmissions.

**Question 8 Do companies agree with formula provided above for calculating the delay for NAS message in downlink without GNSS impact?**

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| **Company** | **Yes/no** | **Comments** |
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For the retransmission factor we consider a small amount of retransmissions.

Table 3

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|  | $$N\_{retransmission factor}$$ | **Delay** |
| LEO (600 km)RTT = 26 ms | 0 | $RTT×0.5≈13 ms$  |
| 2 | $$RTT×2.5≈65 ms$$ |
| 4 | $$RTT×4.5≈117 ms$$ |
| MEO (3500 km)RTT = 60 ms | 0 | $$RTT×0.5≈30 ms$$ |
| 2 | $$RTT×2.5≈150 ms$$ |
| 4 | $$RTT×4.5=270 ms$$ |
| GEO (35768 km)RTT = 542 ms | 0 | $$RTT×0.5=0.27 s$$ |
| 2 | $$RTT×2.5=1.35 s$$ |
| 4 | $$RTT×4.5=2.44 s$$ |

**Question 9 Do companies agree with the values provided in Table 3? If another retransmission factor is preferred, please provide the calculated value together with the preferred retransmission factor.**

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**Question 10 Please state your preference on how the delay values for initial and non-initial as well as downlink NAS are informed in the reply LS. Please state also preferred X or XYZ**

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| **Company** | **Only worse case value with RTT value X** | **Set of values with with RTT values XYZ**  | **Comments** |
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## 2.3 Impact of GNSS

In the WID [6] the UEs with GNSS capability is assumed and the assumption has been that the UE pre-compensate the transmission timing using GNSS position and the position of the satellites.

In RAN1 a couple of agreements related to this are:

Agreement:

* In Rel-17 NR NTN, at least support UE which can derive based on its GNSS implementation one or more of:
	+ its position
	+ a reference time and frequency
* And, based on one or more of these elements together with additional information (e.g., serving satellite ephemeris or timestamp) signalled by the network, can compute timing and frequency, and apply timing advance and frequency adjustment at least for UE in RRC idle/inactive mode.
* In case of GNSS-assisted TA acquisition in RRC idle/inactive mode, the UE calculates its TA based on the following potential contributions:
	+ The User specific TA which is estimated by the UE:
		- Option 1: The User specific TA is estimated by the UE based on its GNSS acquired position together with the serving satellite ephemeris indicated by the network:
			* FFS: Details on serving satellite ephemeris indication
		- Option 2: The User specific TA  is estimated by the UE based on the GNSS acquired reference time at UE together with reference time as indicated by the network
* An NTN UE in RRC\_IDLE and RRC\_INACTIVE states is required to at least support UE specific TA calculation based at least on its GNSS-acquired position and the serving satellite ephemeris.

Related to how or when the UE shall perform GNSS measurements for the purpose of random access, RAN1 has so far not made any agreements. From RAN1 point of view it is likely that when to perform the GNSS measurement is left to UE implementation.

1. From RAN1 point of view there will be no requirements on when the UE shall perform GNSS position acquisition, only that the GNSS position shall be available when computing the pre-compensated Timing Advance.

In [5], a framework for how to calculate the time needed for GNSS measurements is explained. There are three different states, namely hot, warm, and cold, from which the UE may start to perform a first fix and the time to acquire a GNSS fix (TTFF – time to first fix) is explained. In [5], the authors mention TTFF requirements, where from a cold state, the GNSS fix can take up to 100 seconds, from a warm state – 50 s and from hot start – 2 s.

1. The GNSS receiver can have 3 states when performing a GNSS fix; hot, warm and cold where some reference requirements are from 2 to 100 seconds for the time until a first fix.

The problem related to when the UE needs to perform GNSS measurement is that there is a risk that the UE may need to perform GNSS measurement after the NAS or AS timers have already started. This may occur for instance when the UE has not been transmitting any data for a long period, thus no GNSS measurements have been performed for a long period of time.

1. There may be cases when GNSS fix may need to be performed when NAS or AS timers are running according to current procedures.



Figure . Combined delays when performing all of the needed procedures while potential NAS/AS timers are running.

The full procedure along with the time to perform GNSS can be seen in Figure 2.

By not considering the delays such as to acquire system information or perform cell selection and reselection, the potential delays due to the above and with different number of attempts can be calculated as:

$$T\_{initial access}=T\_{message initial access}+TTFF=$$

$$\left(N\_{initial access exchanges}+N\_{retransmission factor}\right)\*RTT+TTFF\_{state}$$

where the $N\_{initial access exchanges}$ is equal to 2.5, which represents the number of message exchanges in case all messages are correctly received and the $N\_{retransmission factor}$ is when a message fails and need to be retransmitted. Instead of detailing the delays of a single message we simplified by introducing the $N\_{retransmission factor}$ and it takes on the values {*0, 0.5, 1, 1.5, …*} depending on which message that fails and how many failures there are during the procedures.

**Question 11 Do companies agree with formula together with analysis on GNSS states provided above for calculating the delay for the GNSS impact?**

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| **Company** | **Yes/no** | **Comments** |
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We consider the three GNSS states as well as the case of GNSS position being available. This can be seen in Table 4 for a number of different cases.

Table 4

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| --- | --- | --- | --- | --- | --- |
|  | $$N\_{retransmission factor}$$ | **Cold state (TTFF = 100s)** | **Warm state (TTFF = 50s)** | **Hot state (TTFF = 2s)** | **GNSS available (TTFF = 0)** |
| LEO (600 km)RTT = 26 ms | 0 | $RTT×2.5+100≈100 s$  | $RTT×2.5+50≈50 s$  | $RTT× 2.5+ 2 ≈2 s$  | $RTT×2.5=0.07 s$  |
| 4 | $$RTT×6.5+100 ≈100 s$$ | $$RTT×6.5+50≈50 s$$ | $$RTT×6.5+2≈2 s$$ | $$RTT×6.5=0.17 s$$ |
| 8 | $$RTT×10.5+100 ≈100 s$$ | $$RTT×10.5+50≈50 s$$ | $$RTT×10.5+2≈2 s$$ | $$RTT×10.5=0.27 s$$ |
| 16 | $$RTT×18.5+100=100.48 s$$ | $$RTT×18.5+50=50.48 s$$ | $$RTT×18.5=2.48 s$$ | $$RTT×18.5=0.48 s$$ |
| MEO (3500 km)RTT = 60 ms | 0 | $$RTT×2.5+100≈100 s$$ | $$RTT×2.5+50≈50 s$$ | $$RTT×2.5+2≈2 s$$ | $$RTT×2.5=0.15 s$$ |
| 4 | $$RTT×6.5+100 ≈100 s$$ | $$RTT×6.5+50≈50 s$$ | $$RTT×6.5+2=2.39 s$$ | $$RTT×6.5=0.39 s$$ |
| 8 | $$RTT×10.5+100=100.63 s$$ | $$RTT×10.5+50=50.63 s$$ | $$RTT×10.5+2=2.63 s$$ | $$RTT×10.5=0.63 s$$ |
| 16 | $$RTT×18.5+100=101.11 s$$ | $$RTT×18.5+50=51.11 s$$ | $$RTT×18.5+2=3.11 s$$ | $$RTT×18.5=1.11 s$$ |
| GEO (35768 km)RTT = 542 ms | 0 | $$RTT×2.5+100=101.355 s$$ | $$RTT×2.5+50=51.355 s$$ | $$RTT×2.5+2=3.355 s$$ | $$RTT×2.5=1.355 s$$ |
| 4 | $$RTT×6.5+100=103.523 s$$ | $$RTT×6.5+50=53.523s$$ | $$RTT×6.5+2=5.523 s$$ | $$RTT×6.5=3.523 s$$ |
| 8 | $$RTT×10.5+100=105.691 s$$ | $$RTT×10.5+50=55.691 s$$ | $$RTT×10.5+2=7.691 s$$ | $$RTT × 10.5=5.691 s$$ |
| 16 | $$RTT×18.5+100=110.03 s$$ | $$RTT×18.5+50=60.03 s$$ | $$RTT×18.5+2=12.03 s$$ | $$RTT × 18.5=10.03 s$$ |

In table 4, we can see the variation of the time that it would take for some NAS procedures. Most severe would be the case when the UE needs to perform GNSS during the access procedures from a cold state and the UE is attempting to connect to a GEO satellite and there are several attempts needed. The time for this scenario can be up to 107 seconds, where the time to perform GNSS is clearly many times larger than what would be needed for performing the initial access procedures. If the UE has GNSS available or is in a hot GNSS state, the time to perform the initial access procedures is clearly lower.

**Question 12 Do companies agree with the values provided in Table 4? If another retransmission factor/GNSS state is preferred, please provide the calculated value together with the preferred retransmission factor/GNSS state.**

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**Question 13 Please state your preference on how the delay values for initial and non-initial as well as downlink NAS are informed in the reply LS. Please state also preferred X or XYZ**

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| **Company** | **Only worst case value with RTT value X****for all GNSS states** | **Set of values with with RTT values XYZ for all GNSS states**  | **Comments e.g. if not all GNSS states are seen relevant** |
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## 2.3 Further discussion on GNSS impact

The problem of the need to potentially perform GNSS fix during initial access procedures in NAS and AS may need to be addressed by either CT1 or RAN2. To solve the problem of the AS and NAS timers, there can be a number of general options:

* **Option 1:** Extend the AS and NAS timers.
	+ **Comments:** Difficult for RAN2 to assess feasibility.
	+ **Pros:** Simple
	+ **Cons:** Could introduce long delays, for instance if the timers take into account that GNSS needs to be performed from a cold state, but the UE implementation performs GNSS measurements regularly to keep a low access delay, or UE has performed GNSS measurements recently.
* **Option 2:** Perform GNSS before any procedures might start
	+ In NAS for instance the UE is instructed to perform GNSS fix before any NAS timer is started, then NAS and AS timers can be as in legacy
	+ **Comments:** difficult for RAN2 to assess this feasibility.
	+ **Pros:** Simple
	+ **Cons:** Introduces new signalling/interactions between NAS and lower layers of the UE. Not possible for the network side AS and NAS timers.
* **Option 3:** Pause any timer while GNSS is performed
	+ **Comments:** difficult for RAN2 to assess this feasibility.
	+ **Pros:** Simple specification-wise.
	+ **Cons:** There are no known timer that is “paused”. Also has similar cons as problem 1 that it may introduce long delays.
* **Option 4:** Require the UE to always be in a hot state so that GNSS TTFF will not take too long.
	+ This can also be combined with the gNB always signaling the A-GNSS.
	+ **Pros:** We can keep our NAS/AS procedures mostly intact. This can be potentially be decided in RAN2.
	+ **Cons:** Potential high UE energy consumption.
* **Option 5:** Different timer values depending on whether UE has performed GNSS or not
	+ **Comments:** difficult for RAN2 to assess the feasibility.
	+ Pros: Could simplify procedures.
	+ Cons: Maybe complicated for NAS to know GNSS state and apply different timer values. This also introduces long delays as in option 1.

It should be noted that it is difficult to judge the feasibility from RAN2 perspective of the solutions.

1. For several alternatives RAN2 cannot judge the feasibility.

For NB-IoT, several AS and NAS timers govern initial access were extended, but it should note that in the case of NB-IoT latency of access and procedures are not really considered important at all. For NR NTN, while low latency is not a use case, user experience may still be affected if some timers are allowed to be excessively long, and it is doubtful whether transport protocols such as TCP could handle a 100 second delay very well.

Instead of pursuing solutions where there is a risk that there will be large amounts of latency, it could be reasonable to require the UE to be in a GNSS state where if a GNSS measurement is needed, the UE shall remain in a state where the GNSS TTFF is not too long where the access delay will be excessively long and have large variations. Thus, we propose that none of the AS timers are extended and the UE is required to remain in hot/warm state or that the UE is required to have a reasonably fresh GNSS location in order to perform random access.

1. RAN2 to assume that the UE either keeps an accurate recent GNSS position or the UE keeps the GNSS in a hot state by implementation.

**Question 14 Do companies agree with proposal 1 and to inform CT1 about it? Note this question is for NR NTN.**

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| **Company** | **Yes/no** | **Comments** |
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# 3 Conclusion

TBA

# 4 References

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