**3GPP TSG-RAN WG2 Meeting #119-eR2-220xxxx**

**Electronic meeting, 17th – 26th Aug,** **2022**

**Agenda item:** 8.2.4

**Source:** CATT

**Title:** [Post119-e][407][POS] LPHAP upper layer enhancements (CATT)

**Document for:** Discussion and Agreement

# 1 Introduction

This is to continue the online discussion on the study of potential LPHAP upper layer enhancements.

* [Post119-e][407][POS] LPHAP upper layer enhancements (CATT)

Scope: Discuss the potential benefits of the candidate higher layer enhancements submitted to RAN2#119-e:

* Optimised paging and/or RRM measurements
* Enhancements of DL and/or UL positioning methods to use MT-SDT
* Enhance SRS configuration request to reduce signalling overhead (including area validity mechanism)
* Event report enhancements
* DL-PRS configuration optimisations
* Exposure of information to the gNB to support RRC state decisions
* Exposure of information to the gNB and/or LPF to identify UEs benefiting from LPHAP enhancements
* Enhancements to the segmentation mechanism for cooperation with LCS messages
* Support of RAT-dependent positioning in RRC\_IDLE

Intended outcome: Report to next meeting

Deadline: Long

Rapporteur would like to have the following schedule for this email discussion to have enough time for preparing the summary report.

* Phase 1: Companies are invited to provide inputs and comments to questions by 2022-09-23rd 22:00 UTC
* Phase 2: Rapporteur will provide draft summary with proposals, companies are invited to provide comments to the summary proposals by 2022-09-29th 10:00 UTC.

The remainder of this document is organized as the following. Section 2 provides Rel-18 SID related to LPHAP. Section 3 contains the questionnaire on potential enhancements which are summarized from the contributions submitted to RAN2#119-e. The purpose is to collect the views and identify the commonalties and differences in order to provide proposals for next meeting, i.e. RAN2#119bis-e.

# 2 Rel-18 SID

According to the SID [1], one objective of the R18 expanded and improved NR positioning is:

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| * Improved accuracy, integrity, and power efficiency:   + Study the requirements on LPHAP as developed by SA1 and evaluate whether existing RAN functionality can support these power consumption and positioning requirements. Based on the evaluation, and, if found beneficial, study potential enhancements to help address any limitations [RAN2, RAN1]     - Study is limited to a single representative use case (use case 6 as defined TS 22.104). The choice of selected use case can be reviewed at the start of the study.     - Study is limited to enhancements to RRC\_INACTIVE and/or RRC\_IDLE state. |

The required operation time of the 5G enabled IoT device and duty cycle of the updated position information for use case 6 defined in TS 22.104 [2] is shown as follow.

Table A.7.2-1: Low power high accuracy positioning use cases

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| Use Case # | Horizontal accuracy | Corresponding service level (22.261) | Positioning interval/ duty cycle | battery life time/ minimum operation time |
| 1 | 10 m | Service Level 1 | on request | 24 months |
| 2 | 2 m to 3 m | Service Level 2 | < 4 seconds | > 6 months |
| 3 | < 1 m | Service Level 3 | no indication | 1 work shift - 8 hours (up to 3 days, 1 month for inventory purposes) |
| 4 | < 1 m | Service Level 3 | 1 second | 6 - 8 years |
| 5 | < 1 m | Service Level 3 | 5 seconds - 15 minutes | 18 months |
| 6 | < 1 m | Service Level 3 | 15 s to 30 s | 6 - 12 months |
| 7 | 30 cm | Service Level 5 | 250 ms | 18 months |
| 8 | 30 cm | Service Level 5 | 1 second | 6 - 8 years (no strong limitation in battery size) |
| 9 | 10 m | Service Level 1 | 20 minutes | 12 years (@20mJ/position fix) |

# 3 LPHAP Upper Layer Enhancements

## 3.1 Optimized paging and/or RRM measurements

In contribution R2-2207111, R2-2208454 and R2-2208626, optimized paging and/or RRM measurements are proposed on purpose of extending the UE battery life by reducing the listening and/or measurement time of UE.

Considering the limited application scenario of use case 6, for some IoT terminals, there may be no other communication requirements apart from the positioning service. So it may be possible to relax the monitoring time and measurements according to the time characteristic of positioning service.

1. Relax the paging: R2-2207111, R2-2208626

* After receiving the positioning request of deferred 5GC-MT-LR, during the whole deferred MT-LR period, NW may not page UE due to positioning requirement.



Figure 1. Paging optimize method[9]

1. MICO-like mode to RRC-INACTIVE/IDLE state: R2-2208454, R2-2208626

* UE may stop paging monitoring, cell re-selection, RAU and so on. The UE behavior in Mobile Initiated Connection Only (MICO) mode can be taken as baseline.

**Q1-1: Do you agree to study optimized paging and/or RRM measurements for power saving?**

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| **Company name** | **Agree/Disagree** | **Comments** |
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**Summary:**

**Q1-2: If you agree to study optimized paging and/or RRM measurements, please provide your views on which of the following solutions do you prefer? You are also welcomed to provide: e.g. performance evaluation of the solutions above, or specify the solutions above in detail.**

**a) Relax the paging;**

**b) MICO-like mode to RRC-INACTIVE/IDLE state;**

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| **Company name** | **Solution(s)** | **Comments** |
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**Summary:**

## 3.2 Enhance DL and/or UL positioning via MT-SDT

In contribution R2-2207083, R2-2207488, R2-2207584 and R2-2208454, enhance positioning via MT-SDT is proposed on purpose of reducing some restrictions of the positioning procedure.

In Rel-17, only MO-SDT was supported in RRC\_INACTIVE positioning. When there is no MO-SDT is initiated by UE, if NW wants to send DL message to UE, NW will trigger the UE transition to RRC\_CONNECTED. This mechanism restricts some procedures, e.g. semi-persistent SRS activation/deactivation and dedicated PRS configuration.

In Rel-18, the Mobile Terminated-Small Data Transmission (MT-SDT) for NR will be supported [3].

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| Specify the support for paging-triggered SDT (MT-SDT) [RAN2, RAN3]   * MT-SDT triggering mechanism for UEs in RRC\_INACTIVE, supporting RA-SDT and CG-SDT as the UL response; * MT-SDT procedure for initial DL data reception and subsequent UL/DL data transmissions in RRC\_INACTIVE.   Note: Data transmission in DL within paging message is not in scope of this WI. |

With supporting MT-SDT, the benefits mentioned in these contributions are summarized as:

* The following restriction for semi-persistent SRS activation/deactivation in RRC\_INACTIVE is removed, so that the can be performed timely;

RAN2#117 Agreements:

Proposal 4 (modified): Support the following options for activation of SP-SRSp transmission in RRC INACTIVE:

- Option a: If there is ongoing SDT, the network can send SRS activation command to the UE in INACTIVE.

- Option b: Send the Activation MAC CE along with the SRSp configuration when gNB releases the UE to RRC\_INACTIVE

Proposal 5 (modified): Support the following for deactivation of SP-SRSp transmission in RRC INACTIVE:

- If gNB chooses to send the SP-SRSp deactivation command to the UE in INACTIVE, gNB can send SP-SRSp deactivation command to the UE if there is ongoing SDT.

- If gNB chooses not to send the SP-SRSp deactivation command to the UE in RRC\_INACTIVE, no additional mechanism is specified (i.e. the gNB can only wait for the TA timer to expire)

* Positioning initiated by MT-LR can be supported. NW can flexibly send LCS/LPP messages including LPP assistance data containing dedicated PRS configurations to the UE, without triggering UE transform to RRC\_CONNECTED state.

**Rapporteur’s comments:**

For the first benefit bullet, the possible power consumption is brought by timely SP-SRSp deactivation to avoid unnecessary SRS transmission. For the second benefit bullet, since service types other than ‘Low Power Periodic and Triggered 5GC-MT-LR Procedures’ has not been confirmed to support in Rel-18 LPHAP, it is not a necessary reason to support MT-SDT.

Considering the starting of study on MT-SDT in Rel-18, and the limited benefits for low power requirement of RRC\_INACTIVE positioning foreseen, “support MT-SDT in Rel-18 positioning” can be treated as low priority in SI.

**Q2-1: Do you agree that “support MT-SDT in Rel-18 positioning” is treated as low priority in SI?**

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| **Company name** | **Agree/Disagree** | **Comments** |
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**Summary:**

**Q2-2: If you disagree to treat “support MT-SDT in Rel-18 positioning” as low priority, please provide your views on: e.g. potential benefits analysis of this candidate enhancement, or specify the mechanism in detail.**

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**Summary:**

## 3.3 Enhance SRS configuration

In contribution R2-2207083, R2-2207089, R2-2207111, R2-2207390, R2-2207584, R2-2207703, R2-2207912, R2-2208128, R2-2208454 and R2-2208626, serval potential enhancements on SRS configuration are proposed on purpose of reducing the frequency of SRS configuration.

In Rel-17, the SRS configuration is considered as valid under the following criteria [4]:

* The inactivePosSRS-TimeAlignmentTimer is running;
* RSRP increased/decreased within *inactivePosSRS-RSRP-ChangeThreshold*;
* No cell re-selection happened after receiving the configuration.

Obviously, the above mentioned criteria restrict the validity of a configured SRS in very limited scope.

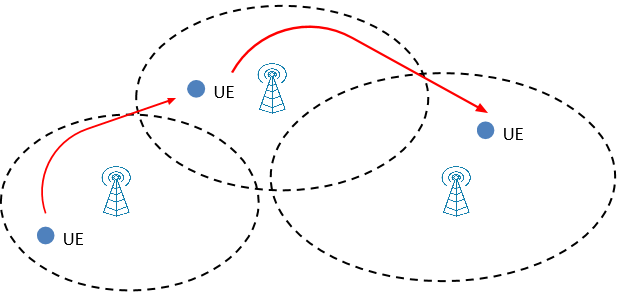


Figure 2. SRS mobility in RRC\_INACTIVE[13]

In Rel-18, for use case 6, the scenario is mainly in factory or industrial park with the positioning requirement of some IoT equipment. The IoT equipment moving in certain range and relatively fixed route, which may span serval cells. Under the mechanism of Rel-17, the SRS configuration may occurs frequently and bring huge signalling overhead together with corresponding energy consumption. To solve this problem, some companies have proposed serval candidate solutions in RAN2#119e, sort as follow:

1. Validity area mechanism: R2-2207083, R2-2207089, R2-2207111, R2-2207390, R2-2207703, R2-2207912, R2-2208128, R2-2208626

* Support area specific SRS along with valid area, that is the configured SRS can be used if the UE is within the valid area. The valid area can cover serval cells.
* R2-2207390 think SRS configurations are valid within a positioning area will waste resources.
* R2-2208078 worry about the interference problem caused by SRS transmission with cross cell mobility.

1. SRS update mechanism: R2-2207083, R2-2208626

* When the UE leaves the valid area and there is an ongoing deferred MT-LR, UE request an updated SRS configuration via SDT and get the updated SRS configuration without entering RRC\_CONNECTED.

1. Pre-configure multiple SRS: R2-2207111, R2-2207584, R2-2208128

* Multiple SRS configuration, which may belong to one or more cells, can be pre-configured to UE by the serving gNB, e.g., by broadcasting in system information.
* R2-2208078 think if configuration is provided in advance, it may not be accurate as UE spatial relation or RSRP.

**Q3-1: Do you agree to study** **enhancements on SRS configuration?**

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**Summary:**

**Q3-2: If you agree to study enhancements on SRS configuration, please provide your views on which of the following solutions do you prefer? You are also welcomed to provide: e.g. performance evaluation of the solutions above, or specify the solutions above in detail.**

**a) Validity area mechanism;**

**b) SRS update mechanism;**

**c) Pre-configure multiple SRS;**

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**Summary:**

## 3.4 Enhance DL-PRS configuration

In contribution R2-2207083, R2-2207390, R2-2207584, R2-2207703 and R2-2208078, serval potential enhancements on PRS configuration are proposed on purpose of reducing power consumption of receiving PRS and/or state transition. The candidate solutions are sort as follow:

1. Simplified PRS configuration: R2-2207584

* Reduce the number of PRS resource or reduce the receive power of a single PRS resource in RRC\_INACTIVE/RRC\_IDLE for LPHAP UE, e.g. limit the PRS frequency layer to 1, limit the PRS symbol to 1, or reduce the configured TRP number.

1. PRS is configured close to SSBs: R2-2207584

* If the time offset between a PRS and a SSB is within 6 ms, UE will be in micro sleep and doesn’t consume ramp-up/ramp-down power. One way is to configure PRS close to SSB’s time position to reduce state transition power.

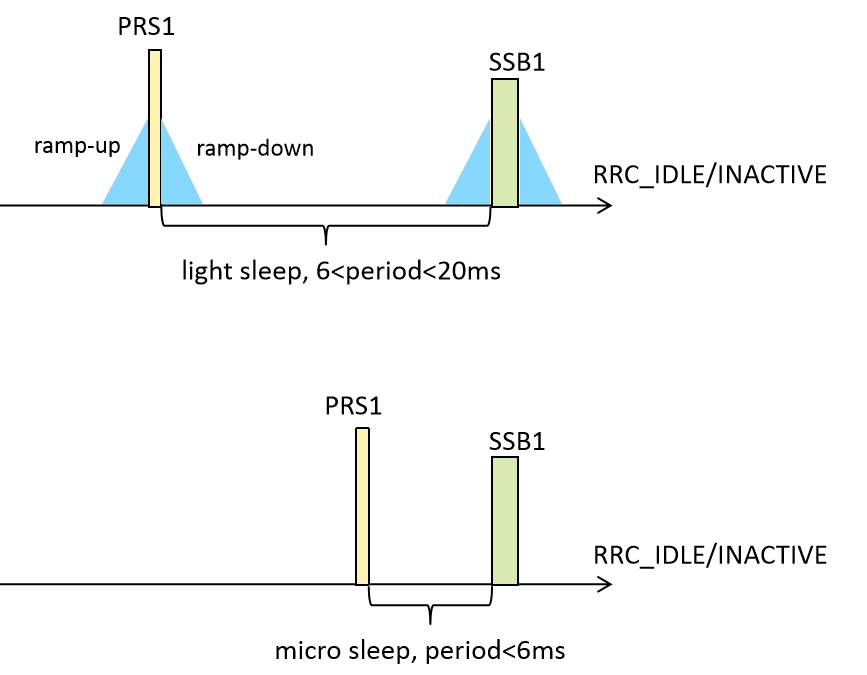


Figure 3. Example of PRS and SSB power consumption when different sleep mode applies [13]

1. Limit PRS reception in a time period: R2-2207584
   * Periodic PRSs come from multiple TRPs and may be distributed in different slots with long interval. One way to reduce the number of state transition is to configure PRS reception only in a limited time period, e.g. PRS reception window, so that the power of receiving PRS can be decreased.

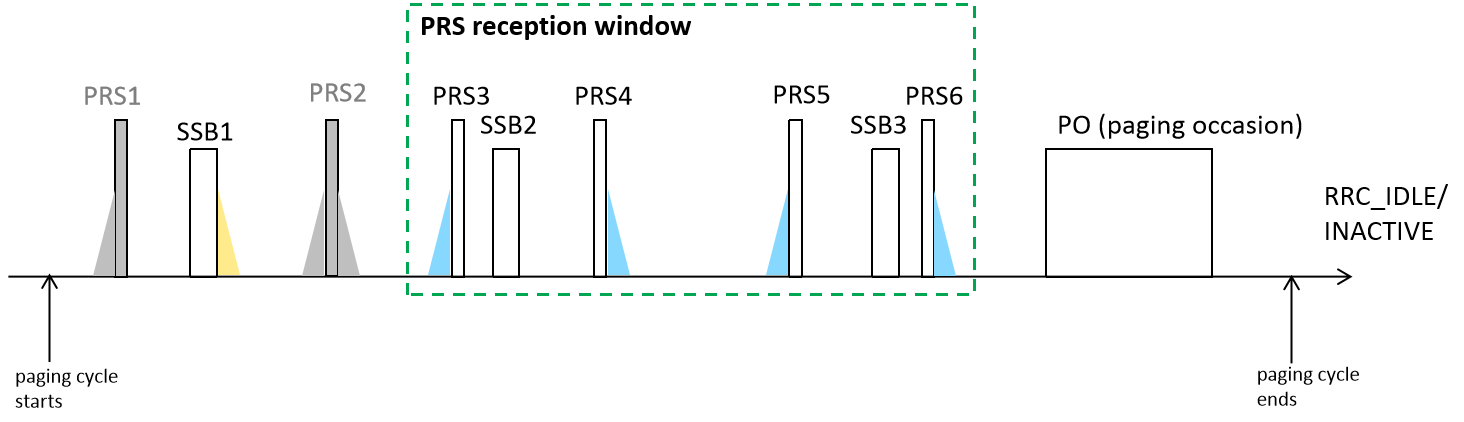


Figure 4. Example of PRS reception window in RRC\_INACTIVE/RRC\_IDLE [13]

1. Configuration alignment between PRS and DRX: R2-2207083, R2-2207111, R2-2207390, R2-2207703, R2-2207830, R2-2208078
   * At present, the (e)DRX information applied by UE and the DL-PRS configured by LMF are independent, which will result in misalignment between PRS reception and the DRX period. Considering aligning DRX and PRS configuration will promote the positioning efficient and reduce some energy consumption. (Similar problem is present for SRS transmission in UL positioning.)



Figure 5. DL-PRS configuration and DRX period [9]

**Q4-1: Do you agree to study** **enhancements on DL-PRS configuration?**

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| **Company name** | **Agree/Disagree** | **Comments** |
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**Summary:**

**Q4-2: If you agree to study enhancements on DL-PRS configuration, please provide your views on which of the following solutions do you prefer? You are also welcomed to provide: e.g. performance evaluation of the solutions above, or specify the solutions above in detail.**

**a) Simplified PRS configuration;**

**b) PRS is configured close to SSBs;**

**c) Limit PRS reception in a time period;**

**d) Configuration alignment between PRS and DRX;**

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**Summary:**

## 3.5 Event report enhancements

In contribution R2-2207083 and R2-2208626, potential enhancements on event report are proposed. These two contributions proposed to skip the event report step in DL and UL positioning procedure separately to reduce the power consumption. The candidate solutions are sort as follow:

1. Enhance event report in DL positioning procedure: R2-2207083

* R2-2207083 proposed the mechanism that if the difference between the two successive measurement results/location estimates is less than a certain threshold, UE report an indication or even skip the report to indicate NW the measurement result is almost unchanged.



Figure 6: Low Power Periodic and Triggered 5GC-MT-LR Procedure with SDT (DL-only and RAT-Independent positioning). [5]

1. Enhance event report in UL positioning procedure: R2-2208626

* In Rel-17, whenever an event is triggered in the deferred MT-LR, the UE needs to send event report to the network. Considering the positioning service is generally fixed and pre-determined for LPHAP, there is no need to use event report to trigger UL positioning.



Figure 7: Low Power Periodic and Triggered 5GC-MT-LR Procedure with SDT (UL-only positioning). [5]

**Q5-1: Do you agree to study** **enhancements on event report?**

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**Summary:**

**Q5-2: If you agree to study enhancements on event report, please provide your views on which of the following solutions do you prefer? You are also welcomed to provide: e.g. performance evaluation of the solutions above, or specify the solutions above in detail.**

**a) Enhance event report in DL positioning procedure;**

**b) Enhance event report in UL positioning procedure;**

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**Summary:**

## 3.6 Exposure of information to the gNB to support RRC state decisions

In contribution R2-2208128, exposure of information to the gNB to support RRC state decisions is discussed.

The AMF may provide the NG-RAN node with expected UE behavior/activity to assist the NG-RAN node with the RRC\_INACTIVE state transition. In case of UE configured with deferred MT-LR, the UE reporting activity – in particular for periodic events – is rather predictable. The UE reporting activity is determined by the IEs periodicLocation, areaEventReporting, or motionEventReporting, which can be considered by the AMF when determining assistance send to gNB. The NG-RAN node may use this information together with the UE capability for RRC\_INACTIVE positioning and SDT-SRB2 to decide on a suitable RRC state.



Figure 8: Initiation of Deferred MT-LR. [18]

**Rapporteur’s comments:**

This issue seems mainly related to the signalling interaction between NG-RAN and AMF which is out of RAN2’s scope.

**Q6-1: Do you agree to study enhancements on “exposure of information to the gNB to support RRC state decisions”?**

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**Summary:**

## 3.7 Exposure of information to the gNB and/or LMF to identify UEs benefiting from LPHAP enhancements

In contribution R2-2207083, R2-2207390 and R2-2207584, exposure information to the gNB and/or LMF to identify UEs benefiting from LPHAP enhancements is proposed.

In case of LPHAP, in order to reduce power consumption, the network may need to relax some configuration. In consequence, it is necessary for the network to know whether the UE is a LPHAP UE. R2-2207584 proposed the following three candidate solutions:

1. RedCap-like solution:

* RedCap UE supports early indication via Msg1/Msg3. After gNB identifies the early indication, gNB send an indication to core network to inform this is a RedCap UE in the initial UE message.
* However they think LPHAP UE can be seen as normal UE during initial access procedure, it is unnecessary to report to NW at that time which may cause negative impact on the system performance of the cell.

1. Direct-to-LMF solution:

* UE capability indicates it is a LPHAP UE, and is directly sent to LMF via LPP message.

1. Direct-to-gNB solution:

* UE capability signaling indicates it is a LPHAP UE, and is directly sent to serving gNB via RRC message.

**Q7-1: Do you agree to study** **enhancements on “Exposure of information to the gNB and/or LMF to identify UEs benefiting from LPHAP enhancements”?**

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**Summary:**

**Q7-2: If you agree to study the enhancement in Q7-1, please provide your views on which of the following solutions do you prefer? You are also welcomed to provide: e.g. performance evaluation of the solutions above, or specify the solutions above in detail.**

**a) RedCap-like solution;**

**b) Direct-to-LMF solution;**

**c) Direct-to-gNB solution;**

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**Summary:**

## 3.8 Enhancements to the segmentation mechanism for cooperation with LCS messages

In contribution R2-2208128, enhancements to the segmentation mechanism for cooperation with LCS messages is discussed.

In the case of an LCS Event Report with embedded LPP message and with LPP message segmentation required, the NAS transport container types would be different for the first LCS Event Report with embedded LPP message segment and all the subsequent LPP message segments. It is currently unclear if such a scenario is "allowed" in the specifications and whether an LMF would be able to handle such a case. They proposed a candidate solution:

* Although UE triggered LPP message is currently not defined, considering UE have the Deferred Routing Identifier, the Additional Information IE of the UL NAS Transport message can be used.
* The LMF would realize from the LPP message in the LCS Event Report that more LPP message segments are on the way and would have to wait for all LPP segments before sending the LCS Event Report Acknowledgement, so the UE knows the LMF received all the LPP message segments.



Figure 9: DL and RAT-Independent Event Reporting with LPP message segmentation.[18]

**Q8-1: Do you agree to study “Enhancements to the segmentation mechanism for cooperation with LCS messages”?**

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**Summary:**

## 3.9 Support of RAT-dependent positioning in RRC\_IDLE

Positioning in RRC\_IDLE state is analyzed and discussed with the following topics.

### 3.9.1 DL positioning

Reference to the outcome of Rel-17 SI on RRC\_IDLE: [6]

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| 10.9 DL positioning measurement in RRC\_IDLE state From a physical layer perspective, it is feasible for a UE to perform DL positioning measurement in RRC\_IDLE state.  - Note: This does not imply that measurements have to be reported in RRC\_IDLE state.  The following procedures are considered as feasible for DL positioning methods in RRC\_IDLE:  - Reporting of DL-PRS measurement and/or location estimate performed in RRC\_IDLE when the UE is in RRC\_INACTIVE/RRC\_CONNETED.  NOTE: The following procedures are considered to have already been supported and can be reused for positioning in RRC\_IDLE  - On-demand SI request in RRC\_IDLE for assistance data delivery by broadcast in RRC\_IDLE  *- ProvideAssistanceData* can be sent in RRC\_CONNECTED for DL-PRS configuration used in RRC\_IDLE downlink positioning  *- RequestLocationInformation* can be sent in RRC\_CONNECTED for DL-PRS measurement and/or location estimate performed in RRC\_IDLE |

At least we can determine that UE can perform PRS measurement in IDLE mode. What we need to study is whether there is feasible DL positioning procedure in RRC\_IDLE state.

In contribution R2-2207083, R2-2207089, R2-2207111, R2-2207390, R2-2207488, R2-2207703, R2-2207912, R2-2208078, the DL positioning in RRC\_IDLE state is analyzed. Several key issues together with some potential directions are summarized as follow:

1. How to configure assistance date to UE in RRC\_IDLE?
2. Via broadcast signalling: R2-2207390, R2-2207703, R2-2208078
3. Pre-configuration: R2-2207390, R2-2207703
4. How to report the positioning measurement?
5. legacy RACH procedure: R2-2207703, R2-2207488
6. legacy PUR design as baseline: R2-2207703
7. measurement in IDLE and report in CONNECTED: R2-2207083, R2-2207089, R2-2208078, R2-2207912
8. The AS context/security problem in RRC\_IDLE;

**Q9-1: Do you agree to study DL** **positioning in RRC\_IDLE?**

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| **Company name** | **Agree/Disagree** | **Comments** |
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**Summary:**

**Q9-2: If you agree to study DL** **positioning in RRC\_IDLE, please provide your views on: e.g. analysis on the related open issues, or specify the potential solutions in detail.**

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| **Company name** | **Solution(s)** | **Comments** |
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**Summary:**

### 3.9.2 UL positioning

In contribution R2-2207083, R2-2207089, R2-2207111, R2-2207488 and R2-2207703, the UL positioning in RRC\_IDLE state is analyzed with several key issues summarized as follow:

* Reference signal selection, e.g., SRS or PRACH;
* How to configure reference signal to UE in RRC\_IDLE;
* How to maintain the UL sync in RRC\_IDLE;
* The AS context/security problem in RRC\_IDLE;

**Q9-3: Do you agree to study UL** **positioning in RRC\_IDLE?**

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| **Company name** | **Agree/Disagree** | **Comments** |
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**Summary:**

**Q9-4: If you agree to study UL** **positioning in RRC\_IDLE, please provide your views on: e.g. analysis on the related open issues, or specify the potential solutions in detail.**

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| **Company name** | **Solution(s)** | **Comments** |
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**Summary:**

# 4 Conclusion

Based on company feedback, the following is observed and proposed:

**TBD:**

# 5 References

1. RP-213588 Revised SID on Study on expanded and improved NR positioning.
2. TS 22.104 Service requirements for cyber-physical control applications in vertical domains.
3. RP-213583 New WI: Mobile Terminated-Small Data Transmission (MT-SDT) for NR.
4. 3GPP TS 38.331 Radio Resource Control (RRC) protocol specification (Release 17).
5. R2-2203949 LS on Positioning in RRC\_INACTIVE State.
6. 3GPP TR 38.857 Study on NR Positioning Enhancements (Release 17).
7. R2-2207083 Discussion on LPHAP vivo discussion Rel-18 FS\_NR\_pos\_enh2
8. R2-2207089 Consideration on LPHAP OPPO discussion Rel-17 FS\_NR\_pos\_enh2
9. R2-2207111 Discussion on LPHAP CATT discussion Rel-18 FS\_NR\_pos\_enh2
10. R2-2207390 Support of LPHAP Intel Corporation discussion Rel-18 FS\_NR\_pos\_enh2
11. R2-2207436 On LPHAP Apple discussion Rel-18 FS\_NR\_pos\_enh2
12. R2-2207488 Discussion on LPHAP InterDigital, Inc. discussion Rel-18 FS\_NR\_pos\_enh2
13. R2-2207584 Discussion on LPHAP ZTE, Sanechips discussion Rel-18 NR\_pos\_enh-Core
14. R2-2207703 Discussion on low power high accuracy positioning Lenovo discussion Rel-18
15. R2-2207830 Considerations on solution for Low Power High Accuracy Positioning Sony discussion Rel-18 FS\_NR\_pos\_enh2
16. R2-2207912 Discussion on LPHA positioning Xiaomi discussion
17. R2-2208078 Discussion on Low Power High Accuracy Positioning Ericsson discussion Rel-18
18. R2-2208128 Limitations of RRC\_INACTIVE positioning for LPHAP Qualcomm Incorporated discussion
19. R2-2208180 Use case and area of focus for LPHAP study Nokia, Nokia Shanghai Bell discussion Rel-18 FS\_NR\_pos\_enh2
20. R2-2208454 Initial considerations on LPHAP CMCC discussion Rel-18 FS\_NR\_pos\_enh2
21. R2-2208626 Discussion on the LPHAP Huawei, HiSilicon, Deutsche Telekom discussion Rel-18 FS\_NR\_pos\_enh2 R2-2207867

# 6 Participants

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| **Company Name** | **Participant name/contact** |
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