**3GPP TSG-RAN WG2 Meeting #113-e *Draft***  ***R2-2100653***

**Electronic Meeting, 25th Jan – 5th Feb 2021**

**Agenda item:** 8.11.2

**Source:** Intel Corporation

**Title:** Text proposal for TR38.857 on latency reduction results

**Document for:**  Discussion and decision

# 1 Introduction

This is to provide text proposal on the latency reduction results based on email discussion as below:

* [Post112-e][616][POS] TP for latency analysis results (Intel)

Scope: Capture the latency analysis results in a TP, taking into account any input from RAN1/RAN3/SA2.

Intended outcome: Endorsable TP

Deadline: Long

Note: RP-202588 is used as the baseline for TR 38.857.

# 2 Text Proposal

**/\*\*\*\*Start of the changes\*\*\*\*/**

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] RP-193237: "new SID on NR Positioning Enhancements".

[3] 3GPP TR 38.855: "Study on NR Positioning (Release 16)".

[4] R1-2009433 Evaluation results for Rel-16 positioning and Rel-17 enhancement Huawei, HiSilicon

[5] R1-2007665 Evaluation of NR positioning performance vivo

[6] R1-2007720 Evaluation of achievable positioning accuracy BUPT

[7] R1-2007754 Evaluation of achievable accuracy and latency ZTE

[8] R1-2007859 Discussion of evaluation of NR positioning performance CATT

[9] R1-2007908 NLOS Identification and Mitigation FUTUREWEI

[10] R1-2009390 Update of Evaluation Results for NR Positioning Performance in I-IoT Scenarios Intel Corporation

[11] R1-2007997 NR Positioning Latency Evaluations Lenovo, Motorola Mobility

[12] R1-2008225 Evaluation of NR positioning in IIOT scenario OPPO

[13] R1-2009555 Results on evaluation of achievable positioning accuracy and latency Nokia, Nokia Shanghai Bell

[14] R1-2009502 Discussion on Performance evaluation of Rel-17 positioning Sony

[15] R1-2008416 Discussions on evaluation of achievable positioning accuracy and latency for NR positioning LG Electronics

[16] R1-2008489 Evaluation of achievable positioning latency InterDigital, Inc.

[17] R1-2009708 Evaluation of achievable Positioning Accuracy & Latency Qualcomm Incorporated

[18] R1-2009428 Evaluation of positioning enhancements Fraunhofer IIS, Fraunhofer HHI

[19] R1-2008720 Positioning evaluation results on potential enhancements for additional use cases CeWiT

[20] R1-2008764 Evaluation of achievable positioning accuracy and latency Ericsson

[21] R1-2008765 Potential positioning enhancements Ericsson

[22] R1-2007666 Discussion on potential positioning enhancements vivo

[23] R1-2005380 Evaluation of achievable positioning accuracy and latency vivo

[24] 3GPP TS 22.261 Service requirements for the 5G system; Stage 1 (Release 17)

[25] RP-202094 Revised SID: Study on NR Positioning Enhancements CATT, Intel Corporation

[26] 3GPP TS 38.901 Study on channel model for frequencies from 0.5 to 100 GHz (Release 16)

[x0] R2-2010872 Summary of latency results Intel Corporation

[x1] 3GPP TS 38.305: "NG Radio Access Network (NG-RAN); Stage 2 functional specification of User Equipment (UE) positioning in NG-RAN".

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**Question 1: Any comments on the changes in clause 2 references?**

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### 5.2.3 Other metrics

#### 5.2.3.1 Latency

##### 5.2.3.1.1 Physical layer Latency

Latency includes higher layer and physical layer latency. Physical layer latency for DL only, UL only, DL+UL positioning solutions for UE-based and UE-assisted approaches are separately studied

The physical layer latency start- and end-time are defined for each positioning method in table 5.2.3.1-1

Table 5.2.3.1-1: Definition of physical layer latency start- and end-time

| Method | Start | End |
| --- | --- | --- |
| UE assisted DL-only & DL-ECID & Multi-RTT | Transmission of the PDSCH from the gNB carrying the LPP Request Location Information message | Successful decoding of the PUSCH carrying the LPP Provide Location Information message |
| UL-only method & UL ECID & Multi-RTT | Reception by the gNB of the NRPPa measurement request message | The transmission by the gNB of the NRPPa measurement response message |
| UE-based | * Alt. 1: transmission of the PUSCH carrying the MG Request from the UE. * Alt. 2: Transmission of the PDSCH from the gNB carrying the LPP message containing the assistance data * Alt. 3: Start of the Reception of DL PRS | Successful decoding of the PUSCH at gNB carrying the LPP Provide Location Information message if applicable, otherwise Calculation of Location Estimate at the UE |

##### 5.2.3.1.2 Higher layer Latency

Higher layer latencies include processing delays of the various involved nodes (UE, gNB, AMF, LMF, etc) and signalling delays between nodes.

The latency assumptions for the various components (UE, gNB, AMF and LMF) used in higher layer latency analysis are defined in table 5.2.3.1.2-1.

Table 5.2.3.1.2-1: Latency Components

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| --- | --- | --- |
| Label | Latency  [ms] | Description |
| Processing Latencies | | |
| TUEProc-RRCReconf | 10 | RRC Reconfiguration processing |
| TUEProc-RRCDLInfo | 5 | RRC DL information transfer |
| TUEProc-RRCULInfo | 2-5 | RRC UL information transfer |
| TUEProc-RRCLocationMeas | 2-5 | RRC Location Measurement Indication |
| TUEProc-LPPCapab | 10-20 | LPP Provide Capabilities |
| TUEProc-LPPAssi | 10 | LPP Provide Assistance Data |
| TUEProc-LPPLocationRe | 5 | LPP Request/Provide Location Information |
| TUEProc-MAC-SRSAct | 1-3 | MAC-CE SRS Activation/Deactivation |
| TgNBProc-RRC | 3 | RRC Processing |
| TgNBProc-NRPPa | 3 | NRPPa Processing |
| TgNBProc-NAS/LPP | 3 | NAS/LPP Processing |
| TAMFProc | 3 | AMF Processing |
| TLMFProc | 3 | LMF Processing |
| Signalling Propagation Delays between Nodes | | |
| TUE-gNB | 0-0.5 |  |
| TgNB-AMF | 3-10 |  |
| TAMF-LMF | 1-10 |  |
| TAMF-GMLC | 3-10 |  |
| Positioning Measurement Latencies | | |
| TLMF-Calc | 2-30 | Position Calculation latency |
| TDL-Meas | 88.5 | Estimated minimum DL PRS measurement time in Rel.16 can be 88.5ms depending on DL PRS configuration settings. |
| TUL-Meas | 12 | SRS for positioning measurement time of 12 ms can be achieved under certain SRS for positioning configuration settings depending on the frame configuration. |

#### 5.2.3.2 Network efficiency

PRS/SRS resource utilization is the metric used to evaluate network efficiency.

#### 5.2.3.3 Device efficiency

The UE power consumption models developed in TR38.840 can be considered as the starting point for defining the UE power consumption model for the evaluation for NR positioning. For evaluations, it is up to each source to detail their methodology (including the power model) for evaluation.

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**Question 2: Any comments on the text proposal in clause 5.2.3.1.2?**

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### 8.1.3 Higher layer latency analysis for Rel-16

#### 8.1.3.1 Latency analysis for DL-TDOA/DL-AoD

Referred to [x1], Figure 8.1.3.1-1 shows the messaging between the LMF, the AMF, the gNBs and the UE to perform DL-TDOA and DL-AoD procedure.



Figure 8.1.3.1-1: DL-TDOA/DL-AoD positioning procedure

The latency performance analysis for UE assisted DL-TDOA and DL-AoD are provided in table 8.1.3.1-1.

Table 8.1.3.1-1: Latency performance analysis for UE assisted DL-TDOA and DL-AoD

| Step | Delay Value [ms] | Description of Latency Component |
| --- | --- | --- |
| Step 1 LPP Request capabilities | 18-34.5 | Processing delays: 14 ms  - UE: TUEProc-RRCDLInfo  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF= 1-10 ms  Note 1: the LPP capability processing delay is counted together in response message. |
| Step 2 LPP Provide Capabilities | 25-54.5 | Processing delays: 21-34 ms  - UE:  - TUEProc-RRCULInfo  - TUEProc-LPPCapab  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5 ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 3 LPP Provide Assistance Data | 28-44.5 | Processing delays: 21-34 ms  - UE:  - TUEProc-RRCDLInfo  - TUEProc-LPPAssi  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5 ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 4 LPP Request Location Information | 23-39.5 | Processing delays: 19 ms  - UE:  - TUEProc-RRCDLInfo  - TUEProc-LPPLocationRe  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 5 RRC Location Measurement Indication | 5-8.5 | Processing delays: 5-8 ms  - UE: TUEProc-RRCLocationMeas  - gNB: TgNBProc-RRC  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB |
| Step 6 RRC Measurement Gap configuration | 13-13.5 | Processing delays: 13 ms  - UE: TUEProc-RRCReconf  - gNB: TgNBProc-RRC  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB |
| Step 7 DL PRS measurement | 88.5 | TDL-Meas |
| Step 8 LPP Provide Location Information | 20-39.5 | Processing delays: 16-19 ms  - UE:  - TUEProc-RRCULInfo  - TUEProc-LPPLocationRe  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5 ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 9 LMF calculation | 2-30 | TLMF-Calc |
| Total values | 222.5-353 |  |

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**Question 3: Any comments on the text proposal on DL-TDOA/AoD?**

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| **Company** | **Comments** |
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#### 8.1.3.2 Latency analysis for UL-TDOA/UL-AoA

Referred to [x1], Figure 8.1.3.2-1 shows the messaging between the LMF, the AMF, the gNBs and the UE to perform UL-TDOA and UL-AoA procedure.



Figure 8.1.3.2-1: UL-TDOA/UL-AoA positioning procedure

The latency performance analysis for UE assisted UL-TDOA and UL-AoA are provided in table 8.1.3.2-1.

Table 8.1.3.2-1: Latency performance analysis for UE assisted UL-TDOA and UL-AoA

| Step | Delay Value [ms] | Description of Latency Component |
| --- | --- | --- |
| Step 1 LPP Request capabilities | 18-34.5 | Processing delays: 14 ms  - UE: TUEProc-RRCDLInfo  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF= 1-10 ms  Note 1: the LPP capability processing delay is counted together in response message.  Note 2: Should not be counted if the LMF does not need the capability, e.g. only use Rel-15 SRS for UL positioning. |
| Step 2 LPP Provide Capabilities | 25-54.5 | Processing delays: 21-34 ms  - UE:  - TUEProc-RRCULInfo  - TUEProc-LPPCapab  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5 ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 3 NRPPa POSITIONING INFORMATION REQUEST | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 4 RRC SRS configuration | 13-13.5 | Processing delays: 13 ms  - UE: TUEProc-RRCReconf  - gNB: TgNBProc-RRC  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB  Note 3: Should not be counted if the SRS configuration has been configured before the procedure. |
| Step 5 NRPPa POSITIONING INFORMATION RESPONSE | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 6 NRPPa Request UE SRS activation | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF  Note 4: Should not be counted if the periodic SRS is used. |
| Step 7 MAC Activate UE SRS transmission | 1-3.5 | Processing delays: 13ms  - UE: TUEProc-MAC-SRSAct  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB  Note 5: Should not be counted if the periodic or aperiodic SRS is used. |
| Step 8 NRPPa Request UE SRS activate Response | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF  Note 6: Should not be counted if the periodic SRS is used. |
| Step 9 NRPPa MEASUREMENT REQUEST | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 10 UL SRS measurement | 12 | TUL-Meas |
| Step 11 NRPPa MEASUREMENT RESPONSE | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 12 LMF calculation | 2-30 | TLMF-Calc |
| Total values | 149-322 |  |

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**Question 4: Any comments on the text proposal on UL-TDOA/AoA?**

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| **Company** | **Comments** |
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#### 8.1.3.3 Latency analysis for Multi-RTT

Referred to [x1], Figure 8.1.3.3-1 shows the messaging between the LMF, the AMF, the gNBs and the UE to perform Multi-RTT procedure.



Figure 8.1.3.3-1: Multi-RTT positioning procedure

The latency performance analysis for UE assisted Multi-RTT are provided in table 8.1.3.3-1.

Table 8.1.3.3-1: Latency performance analysis for UE assisted Multi-RTT

| Step | Delay Value [ms] | Description of Latency Component |
| --- | --- | --- |
| Step 1 LPP Request capabilities | 18-34.5 | Processing delays: 14 ms  - UE: TUEProc-RRCDLInfo  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF= 1-10 ms  Note 1: the LPP capability processing delay is counted together in response message. |
| Step 2 LPP Provide Capabilities | 25-54.5 | Processing delays: 21-34 ms  - UE:  - TUEProc-RRCULInfo  - TUEProc-LPPCapab  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5 ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 3 NRPPa POSITIONING INFORMATION REQUEST | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 4 RRC SRS configuration | 13-13.5 | Processing delays: 13 ms  - UE: TUEProc-RRCReconf  - gNB: TgNBProc-RRC  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB  Note 3: Should not be counted if the SRS configuration has been configured before the procedure. |
| Step 5 NRPPa POSITIONING INFORMATION RESPONSE | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 6 NRPPa Request UE SRS activation | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF  Note 4: Should not be counted if the periodic SRS is used. |
| Step 7 MAC Activate UE SRS transmission | 1-3.5 | Processing delays: 13ms  - UE: TUEProc-MAC-SRSAct  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB  Note 5: Should not be counted if the periodic or aperiodic SRS is used. |
| Step 8 NRPPa Request UE SRS activate Response | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF  Note 6: Should not be counted if the periodic SRS is used. |
| Step 9 NRPPa MEASUREMENT REQUEST | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF  Note 7: Step 9 (NRPPa Measurement Request) can be performed in parallel with Steps 10/11 (LPP signalling). Hence, only the bigger number of the two procedures are considered (i.e., the latency for NRPPa Measurement Request is not counted in the summation). |
| Step 10 LPP Provide Assistance Data | 28-44.5 | Processing delays: 21-34 ms  - UE:  - TUEProc-RRCDLInfo  - TUEProc-LPPAssi  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5 ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 11 LPP Request Location Information | 23-39.5 | Processing delays: 19 ms  - UE:  - TUEProc-RRCDLInfo  - TUEProc-LPPLocationRe  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 12 RRC Location Measurement Indication | 5-8.5 | Processing delays: 5-8 ms  - UE: TUEProc-RRCLocationMeas  - gNB: TgNBProc-RRC  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB |
| Step 13 RRC Measurement Gap configuration | 13-13.5 | Processing delays: 13 ms  - UE: TUEProc-RRCReconf  - gNB: TgNBProc-RRC  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB |
| Step 14 a DL PRS measurement | 88.5 | TDL-Meas |
| Step 14 b UL SRS measurement | 12 | TUL-Meas |
| Step 15 LPP Provide Location Information | 20-39.5 | Processing delays: 16-19 ms  - UE:  - TUEProc-RRCULInfo  - TUEProc-LPPLocationRe  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5 ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 16 NRPPa MEASUREMENT RESPONSE | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF  Note 8: Step 16 (NRPPa Measurement Response) can be performed in parallel with Step 15 (LPP Provide Location Information). The UL- and DL- measurements are made concurrently, hence the results are send at about the same time. Only the bigger number of the two procedures need to be considered (i.e., the latency for NRPPa Measurement Response is not counted in the summation). |
| Step 17 LMF calculation | 2-30 | TLMF-Calc |
| Total values | 249.5-422.5 |  |

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**Question 5: Any comments on the text proposal on Multi-RTT?**

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| **Company** | **Comments** |
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#### 8.1.3.4 Latency analysis for NR E-CID

Referred to [x1], Figure 8.1.3.4-1 shows the messaging between the LMF, the AMF, the gNBs and the UE to perform Downlink NR E-CID procedure.



Figure 8.1.3.4-1: Downlink NR E-CID positioning procedure

The latency performance analysis for Downlink NR E-CID are provided in table 8.1.3.3-1.

Table 8.1.3.4-1: Latency performance analysis for Downlink NR E-CID

| Step | Delay Value [ms] | Description of Latency Component |
| --- | --- | --- |
| Step 1 LPP Request capabilities | 18-34.5 | Processing delays: 14 ms  - UE: TUEProc-RRCDLInfo  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF= 1-10 ms  Note 1: the LPP capability processing delay is counted together in response message. |
| Step 2 LPP Provide Capabilities | 25-54.5 | Processing delays: 21-34 ms  - UE:  - TUEProc-RRCULInfo  - TUEProc-LPPCapab  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5 ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 3 LPP Request Location Information | 23-39.5 | Processing delays: 19 ms  - UE:  - TUEProc-RRCDLInfo  - TUEProc-LPPLocationRe  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 4 UE measurement |  | Note 2: not counted; |
| Step 5 LPP Provide Location Information | 20-39.5 | Processing delays: 16-19 ms  - UE:  - TUEProc-RRCULInfo  - TUEProc-LPPLocationRe  - gNB: TgNBProc-NAS/LPP  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20.5 ms  - UE-gNB: TUE-gNB  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 6 LMF calculation | 2-30 | TLMF-Calc |
| Total values | 88-198 |  |

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**Question 6: Any comments on the text proposal on Downlink NR E-CID?**

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| **Company** | **Comments** |
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Referred to [x1], Figure 8.1.3.4-2 shows the messaging between the LMF, the AMF, the gNBs and the UE to perform Uplink NR E-CID procedure.



Figure 8.1.3.4-2: Uplink NR E-CID positioning procedure

The latency performance analysis for Uplink NR E-CID are provided in table 8.1.3.3-1.

Table 8.1.3.4-2: Latency performance analysis for Uplink NR E-CID

| Step | Delay Value [ms] | Description of Latency Component |
| --- | --- | --- |
| Step 1 NRPPa E-CID Measurement Initiation Request | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 2 RRC Measurement/SRS configuration | 13-13.5 | Processing delays: 13 ms  - UE: TUEProc-RRCReconf  - gNB: TgNBProc-RRC  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB  Note 1: Should not be counted if the configuration has been configured before the procedure. |
| Step 3 MAC Activate UE SRS transmission | 1-3.5 | Processing delays: 13ms  - UE: TUEProc-MAC-SRSAct  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB  Note 2: Should not be counted if the periodic or aperiodic SRS is used. |
| Step 4 UL measurement | 12 | TUL-Meas |
| Step 5 RRC Measurement report | 5-8.5 | Processing delays: 5-8 ms  - UE: TUEProc-RRCULInfo  - gNB: TgNBProc-RRC  Signalling delay:0-0.5ms  - UE-gNB: TUE-gNB  Note 3: should not be counted if the gNB already has valid measurement results from the UE. |
| Step 6 NRPPa E-CID Measurement Initiation Response | 13-29 | Processing delays: 9 ms  - gNB: TgNBProc-NRPPa  - AMF: TAMFProc  - LMF: TLMFProc  Signalling delay:4-20 ms  - gNB-AMF: TgNB-AMF  - AMF-LMF: TAMF-LMF |
| Step 7 LMF calculation | 2-30 | TLMF-Calc |
| Total values | 59-125.5 |  |

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**Question 7: Any comments on the text proposal on Uplink NR E-CID?**

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### 8.2.3 Higher layer latency analysis for NR positioning enhancements

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## 8.4 Summary of performance evaluations

Performance analysis of baseline I-IoT InF scenarios shows that InF-SH scenario (Scenario 1) is characterized by high probability of LOS links. In InF-DH (Scenario 2) the probability of LOS links is reduced substantially while probability of NLOS links is increased accordingly.

For the case without modeling synchronization and gNB/UE TX/RX timing errors in the InF-SH scenario (Scenario 1).

* + - Based on the results provided by a majority of sources, sub-meter level @ 90% of horizontal positioning accuracy is achieved by Rel.16 solutions.
    - For horizontal accuracy, results were provided by 13 sources([4], [6], [7], [8], [9], [12], [13], [14], [19], [20], [17], [5], [10]) out of 17 sources for FR1 and by 9 sources ([4], [6], [7], [8], [14], [20], [17], [5], [10]) out of 17 for FR2
* For NR positioning evaluations in FR1 band, the following is observed with respect to horizontal positioning accuracy:
  1. Accuracy of ≤ 0.2m @ 90% is achieved in contributions from 4 sources ([8, [20], [5],[17]) and is not achieved in contributions from 9 sources ([4], [6], [7], [9], [12], [13], [14], [19], [10])
  2. Accuracy of ≤ 0.5m @ 90% is achieved in contributions from 6 sources ([4], [8], [20], [17], [5], [10])and is not achieved in contributions from 7 sources ([6], [7], [9], [12], [13], [14], [19])
* For NR positioning evaluations in FR2 band, the following is observed with respect to horizontal positioning accuracy:
  1. Accuracy of ≤ 0.2m @ 90% is achieved in contributions from [7] ([4],[7], [8], [20], [17], [5], [10])sources and is not achieved in contributions from 2 sources ([6], [14])
  2. Accuracy of ≤ 0.5m @ 90% is achieved in contributions from 9 sources ([4], [6], [7], [8], [14], [20], [17], [5] ,[10]) and is not achieved in contributions from 0 sources
     + For vertical accuracy, results were provided by 4 sources ([7], [8], [5], [10]) out of 17 for FR1 and by 4 sources ([7], [8], [17], [10]) out of 17 for FR2 band
* For NR positioning evaluations in FR1 band, the following is observed with respect to vertical positioning accuracy:
  1. Accuracy of ≤ 1m @ 90% is achieved in contribution from 2 sources ([7], [5]) and is not achieved from 2 sources ([8], [10])
* For NR positioning evaluations in FR2 band, the following is observed with respect to vertical positioning accuracy:
  1. Accuracy of ≤ 1m @ 90% is achieved in contribution from 4 sources ([7], [8], [17], [10]) [and is not achieved by 0 sources]

For the case without modeling synchronization and gNB/UE TX/RX timing errors in the baseline InF-DH scenario (Scenario 2), including evaluations with variable gNB/UE heights for vertical accuracy

* Based on the results provided by a majority of sources, sub-meter level @ 90% of horizontal positioning accuracy is not achieved by Rel.16 based solutions.
* For horizontal accuracy, results were provided by 14 sources ([4], [6], [7], [8], [9], [12], [13], [14], [19], [20], [17], [5], [10], [18]) out of 17 for FR1 and by 9 sources ([4], [6], [7], [8], [14], [20], [17], [5], [10]) out of 17 for FR2
* For NR positioning evaluations in FR1 band, the following is observed with respect to horizontal positioning accuracy:

1. Accuracy of ≤ 0.2m @ 90% is achieved in contribution from [3] sources ([8],[17],[5]) and is not achieved in contributions from 11 sources ([4], [6], [7], [9], [12], [13], [14], [19], [20], [10], [18])
2. Accuracy of ≤ 0.5m @ 90% is achieved in contributions from 4 sources ([6], [8], [17], [5]) and is not achieved in contributions from 10 sources ([4], [7], [9], [12], [13], [14], [19], [20], [10], [18])

* For NR positioning evaluations in FR2 band, the following is observed with respect to horizontal positioning accuracy:
  1. Accuracy of ≤ 0.2m @ 90% is achieved in contributions from 4 sources ([6], [17], [5], [8]) and is not achieved in contributions from 6 sources ([4], [7],, [14], [20], [10])
  2. Accuracy of ≤ 0.5m @ 90% is achieved in contributions from 4 sources ([6], [17], [5], [8]) and is not achieved in contributions from 6 sources ([4], [7], [14], [20], [10])
     + For vertical accuracy, results were provided by 6 sources ([7], [8], [5], [10], [4], [18]) out of 17 for FR1 and by 4 sources ([7], [8], [10], [4]) out of 17 for FR2 band
* For NR positioning evaluations in FR1 band, the following is observed with respect to vertical positioning accuracy:
  1. Accuracy of ≤ 1m @ 90% is achieved in contribution from 2 sources ([8], [5]) and is not achieved from 4 sources ([7], [10], [4], [18])
* For NR positioning evaluations in FR2 band, the following is observed with respect to vertical positioning accuracy:
  1. Accuracy of ≤ 1m @ 90% is achieved in contribution from 1 source ([4]) and is not achieved from [3] sources ([7], [8], [10])

For the issues related to mitigating effects of multipath/NLOS for positioning

* Evaluation results for LOS/NLOS identification, outlier rejection, NLOS mitigation based on triangle inequality algorithms in indoor factory scenarios were provided by 12 sources ([12], [9], [5], [10], [17], [7], [4], [19], [13], [14], [18], [20]) out of 17 sources
* NR positioning utilizing LOS/NLOS identification, outlier rejection, NLOS mitigation based on triangle inequality algorithms improve performance of positioning accuracy with respect to solutions that do not apply these techniques
* From the evaluations,
  + 9 sources ([9], [10], [7], [4], [19], [13], [14], [18], [20]) evaluated LOS/NLOS identification with additional specification changes relative to Rel.16 solutions
  + 2 sources ([5], [17]) evaluated outlier rejection algorithm (implementation-based algorithm that can be applied for Rel.16 solutions without specification changes)
  + 1 source ([12]) evaluated NLOS mitigation using triangle-based inequality algorithm (implementation-based algorithm that can be applied for Rel.16 solutions without specification changes)
* Comparative analysis of LOS/NLOS identification with specification changes vs implementation based methods (outlier rejection algorithms) was done by 6 sources ([10], [4], [5], [17], [7], [12])
  + Three sources ([10], [4], [7]) observe that NR positioning based on LOS/NLOS identification outperforms NR positioning utilizing outlier rejection
  + Three sources ([5], [17], [12]) observe that NR positioning utilizing outlier rejection outperforms NR positioning utilizing LOS/NLOS identification

For issues related to gNB/UE TX/RX timing errors

* Evaluation results of gNB/UE TX/RX timing errors (as per the optional model) are provided by 7 sources ([4], [7], [17], [10], [8], [20], [5]) out of 17 sources)
* Summary of results is provided in tables B.1-1 to B.1-4

For the issues related to aggregation of DL positioning frequency layers:

* Evaluation results for aggregation of DL positioning frequency layers were provided by 5 sources ([10], [17], [4], [22], [20]) out of 17.
* Aggregation of NR positioning frequency layers improves positioning accuracy under certain scenarios, configurations, and assumptions on modelled impairments such as: bandwidth and spacing of aggregated layers, timing offset and frequency offset over frequency layers, phase discontinuity and possible amplitude imbalance.
  + One source ([4]) observes that aggregation with phase continuity can help to improve the positioning accuracy, and discontinuous aggregation can approach the performance of contiguous aggregation with the same frequency span
  + One source ([10]) has shown that aggregation of frequency layers (without modeling impairments) improves the positioning accuracy for intra-band contiguous configuration and that further study is needed for other cases including impairments
  + One source ([20]) has observed that PRS aggregation shows potential gains without modeling phase error, but these gains are lost when the phase error between CCs becomes too large
  + One source ([17]) has analyzed aggregation of 2 and 4 frequency layers for different channel spacings, time and phase offset across frequency layers
  + One source ([22] has analyzed aggregation of 2 frequency layers for different time offset values and observed that:
* For the case without impairments modeling, aggregation of multiple DL positioning frequency layers 50MHz+50MHz, performance target [0.2m @ 90%] cannot be achieved in both InF-SH and InF-DH.
* For the case without impairments modeling, aggregation of multiple DL positioning frequency layers 50MHz+50MHz, the performance is worse than 100MHz but better than 50MHz.
* The performance of aggregation of frequency layers degrades if timing offset is increased

For issues related to physical layer latency for Rel.16 DL-TDOA/DL-AOD

* Summary of results is provided in table B.2-1
* Summary of physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning in FR1 was provided by 11 sources
* Summary of physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning in FR2 was provided by 5 sources
* For evaluation in FR1,
  + results from 11 sources out of 11 sources ([17], [4], [7], [5], [11], [15], [8], [13], [12], [16], [10]) show that minimum estimated physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning exceeds 10ms
  + results from [2] ([7], [10]) sources out of 11 sources ([17], [4], [7], [5], [11], [15], [8], [13], [12], [16], [10]) show that minimum estimated physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning exceeds 100ms
* For evaluation in FR2,
  + results from 5 sources out of 5 sources ([7], [5], [11], [12],[13]) show that minimum estimated physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning exceeds 10ms
  + results from 2 ([7], [5]) sources out of 4 sources ([7], [5], [11], [12]) show that minimum estimated physical layer latency for Rel.16 DL-TDOA/DL-AOD UE-assisted NR positioning exceeds 100ms
* The following list provides the major physical layer latency components for Rel.16 DL TDOA/DL-AOD UE-assisted NR Positioning
  + DL PRS alignment, transmission, measurement (including processing time) and report delay
  + Measurement gap request, configuration and alignment time
  + UE/gNB higher layer (LPP/RRC) processing times

For issues related to physical layer latency for Rel.16 UL-TDOA/UL-AOA

* Summary of results is provided in table B.2-2
* Summary of physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning in FR1 was provided by 8 sources ([4], [5], [15], [8], [13], [12], [16], [10])
* Summary of physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning in FR2 was provided by 2 sources ([5], [12])
* For evaluation in FR1,
  + results from [3] sources ([4], [8], [13]) out of 8 sources ([4], [5], [15], [8], [13], [12], [16], [10]) show that minimum estimated physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning does not exceed 10ms
  + results from 8 sources out of 8 sources ([4], [5], [15], [8], [13], [12], [16], [10]) show that minimum estimated physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning does not exceed 100ms
* For evaluation in FR2,
  + results from 2 sources out of 2 sources ([5], [12]) show that minimum estimated physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning exceeds 10ms
  + results from [1] ([12]) sources out of 2 sources ([5], [12]) show that minimum estimated physical layer latency for Rel.16 UL-TDOA/UL-AOA NR positioning does not exceed 100ms
* The following list provides the major physical layer latency components for Rel.16 UL-TDOA/UL-AOA NR Positioning
  + SRS for positioning processing time
  + SRS for positioning alignment time (depends on periodic or aperiodic SRS for positioning)
  + gNB higher layer processing delays (RRC/ NRPPa processing times)

For issues related to physical layer latency for Rel.16 Multi-RTT

* Summary of results is provided in table B.2-3
* Summary of physical layer latency for Rel.16 Multi-RTT UE-assisted NR positioning in FR1 was provided by 6 sources ([17], [4], [5], [15], [16], [10])
* Summary of physical layer latency for Rel.16 Multi-RTT UE-assisted NR positioning in FR2 was provided by 0 sources
* For evaluation in FR1,
  + results from 6 sources ([17], [4], [5], [15], [16], [10]) out of 6 sources ([17], [4], [5], [15], [16], [10]) show that minimum estimated physical layer latency for Rel.16 Multi-RTT UE-assisted NR positioning exceeds 10ms
  + results from 4 sources ([17], [4], [5], [16]) out of 6 sources ([17], [4], [5], [15], [16], [10]) show that minimum estimated physical layer latency for Rel.16 Multi-RTT UE-assisted NR positioning does not exceed 100ms
* The following list provides the major physical layer latency components for Rel.16 Multi-RTT UE-assisted NR positioning
  + DL PRS alignment, transmission, measurement time and report delay
  + Measurement gap request, configuration, alignment time
  + SRS for positioning processing time
  + SRS for positioning alignment time (depends on periodic or aperiodic SRS for positioning)
  + UE/gNB higher layer (LPP/RRC/NRPPa) processing times

For issues related to physical layer latency for Rel.16 E-CID NR positioning

* Summary of results is provided in table B.2-4
* Summary of physical layer latency for Rel.16 E-CID NR positioning in FR1 was provided by [3] sources ([4], [7], [15])
* Summary of physical layer latency for Rel.16 E-CID NR positioning in FR2 was provided by 0 sources
* For evaluation in FR1,
  + results from 2 sources ([7], [15]) out of 3 sources ([4], [7], [15]) show that minimum estimated physical layer latency for Rel.16 E-CID NR positioning exceeds 10ms
  + results from [3] sources ([4], [7], [15]) out of 3 sources ([4], [7], [15]) show that minimum estimated physical layer latency for Rel.16 E-CID NR positioning does not exceed 100ms
* The following list provides the major physical layer latency components for Rel.16 E-CID NR positioning
  + Higher layer signaling processing

For issues related to physical layer latency for Rel.16 DL-only UE-based NR positioning

* Summary of results is provided in table B.2-5
* Summary of physical layer latency for Rel.16 DL-only UE-based NR positioning in FR1 was provided by 6 sources ([17], [4], [5], [11], [12], [16])
* Summary of physical layer latency for Rel.16 DL-only UE-based NR positioning in FR2 was provided by 2 sources ([5], [11])
* For evaluation in FR1,
  + results from 4 sources ([4], [5], [12], [16]) out of 6 sources ([17], [4], [5], [11], [12], [16]) show that minimum estimated physical layer latency for Rel.16 DL-only UE-based NR positioning exceeds 10ms
  + results from 6 sources out of 6 sources ([17], [4], [5], [11], [12], [16]) show that minimum estimated physical layer latency for Rel.16 DL-only UE-based NR positioning does not exceed 100ms
* For evaluation in FR2,
  + results from 2 sources out of 2 sources ([5], [11]) show that minimum estimated physical layer latency for Rel.16 DL-only UE-based NR positioning exceeds 10ms
  + results from [1] ([5]) sources out of 2 sources ([5], [11]) show that minimum estimated physical layer latency for Rel.16 DL-only UE-based NR positioning exceeds 100ms
* The following list provides the major physical layer latency components for Rel.16 DL-only UE-based NR positioning
  + DL PRS alignment, transmission, measurement time and, if requested, report delay
  + Measurement gap request, configuration, alignment time
  + Higher layer (LPP/RRC) processing times

For issues related to higher layer latency for Rel.16 DL-TDOA/DL-AOD

* Summary of results is provided in table 8.1.3.1-1

For issues related to higher layer latency for Rel.16 UL-TDOA/UL-AOA

* Summary of results is provided in table 8.1.3.2-1

For issues related to higher layer latency for Rel.16 Multi-RTT

* Summary of results is provided in table 8.1.3.3-1

For issues related to higher layer latency for Rel.16 NR E-CID positioning

* Summary of results for Downlink NR E-CID is provided in table 8.1.3.4-1
* Summary of results for Uplink NR E-CID is provided in table 8.1.3.4-2

For the case without modeling synchronization and gNB/UE TX/RX timing errors in the UMa scenario

* Based on the results provided, 10 m level @ 90% of horizontal positioning accuracy is achieved by Rel.16 in UMa scenario
* Results were provided by 2 sources ([20], [17]) out of 17 for FR1 band
* For NR positioning evaluations for UMa scenario in FR1 band, the following is observed with respect to horizontal positioning accuracy:

1. Accuracy of ≤ 1m @ 80% is achieved for the outdoor UEs in contributions from 1 source ([17]) out of 2 sources ([20], [17]) in the scenario without absolute time of arrival modelling. Zero sources met an accuracy of ≤ 1m @ 90%.
2. Accuracy of ≤ 10m @ 90% is achieved for the outdoor UEs in contributions from 2 sources ([20], [17]) out of 2 sources in the scenario without absolute time of arrival modelling
3. Accuracy of ≤ 10m @ 90% is achieved for the indoor UEs in contributions from 1 source ([20]) out of 2 sources in the scenario without absolute time of arrival modelling

For the case without modeling synchronization and gNB/UE TX/RX timing errors in the UMi scenario

* Results were provided by 4 sources ([13], [20], [17], [18]) out of 17 for FR1 band
* For NR positioning evaluations for UMi scenario in FR1 band, the following is observed with respect to horizontal positioning accuracy:

1. Accuracy of ≤ 1m @ 90% is achieved in contributions from 2 sources ([20], [17]) and is not achieved from 2 sources ([13], [18]) in the scenario without absolute time of arrival modelling

Accuracy of ≤ 1m @ 90% is not achieved from 2 sources ([17], [18]) in a scenario with absolute time of arrival modelling

* For NR positioning evaluations for UMi scenario in FR2 band, the following is observed with respect to horizontal positioning accuracy:

1. Accuracy of ≤ 1m @ 90% is achieved in contributions from 1 source ([17]]) in the scenario without absolute time of arrival modelling.

For the case without modeling synchronization and gNB/UE TX/RX timing errors in the IOO scenario

* Based on the results provided by a majority of the sources, 1 m level @ 90% of horizontal positioning accuracy is achieved by Rel.16 in IOO scenario
* Results were provided by 5 sources ([8], [13], [14], [20], [23]) out of 17 for FR1 and 5 sources ([8], [14], [20], [17], [23]) out of 17 for FR2 band
* For NR positioning evaluations for IOO scenario in FR1 band, the following is observed with respect to horizontal positioning accuracy:

1. Accuracy of ≤ 1m @ 90% is achieved in contributions from 4 sources ([8], [14], [20], [23]) and is not achieved from 1 source ([13]) in the scenario without absolute time of arrival modelling
2. Accuracy of ≤ 1m @ 90% is achieved from 1 source ([23]) in a scenario with absolute time of arrival modelling

* For NR positioning evaluations for IOO scenario in FR2 band, the following is observed with respect to horizontal positioning accuracy:

1. Accuracy of ≤ 1m @ 90% is achieved in contributions from 5 sources ([8], [14], [20], [17], [23]) in the scenario without absolute time of arrival modelling
2. Accuracy of ≤ 1m @ 90% is achieved from 1 source ([23]) in a scenario with absolute time of arrival modelling

The results for the UE efficiency (power saving) in the RRC\_IDLE/RRC\_INACTIVE states were analyzed by 2 sources ([4], [5]) out of 17 sources (assumptions may be different between the different sources)

* In one source ([4]), the following observations were made:
  + RRC\_IDLE/RRC\_INACTIVE state positioning can save about 7%-40% power consumption compared to C-DRX configuration
* In one source ([5]), the following observations were made:
  + Positioning report in the RRC\_IDLE state can provide 44.32 % of power saving gain compared to the report in the RRC\_CONNECTED state
  + Positioning measurement and report in the RRC\_IDLE state can provide at least 48.38 % of power saving gain compared to the measurement and report in the RRC\_CONNECTED state

The results for the PRS resource utilization were analyzed by 3 sources ([4], [5], [8]) out of 17 sources

* In one source ([4]), the PRS resource utilization was evaluated for the case of 160 ms DL PRS periodicity, 30 kHz subcarrier spacing, and 12, 4, and 1 symbol per PRS resource:
  + PRS with 12, 4, and 1 symbol has positioning resource utilization of 2.14 %, 0.714 %, and 0.179 %, respectively
* In one source ([5]), the PRS resource utilization was evaluated:
  + In FR1, for 20 ms DL PRS periodicity and MG periodicity, 3ms MGL, 30 kHz subcarrier spacing, comb 6 and 6 symbols per PRS resource, 18 positioning sites and 1 beams per site, PRS resource utilization is 3.21% while the MGL/MGRP (UE overhead) is 15%.
  + In FR2, for 20 ms DL PRS periodicity, 20ms for MGL and MGRP, 120 kHz subcarrier spacing, comb 6 and 6 symbols per PRS resource, 18 positioning sites and 64 beams per site, PRS resource utilization is 51.42% while the MGL/MGRP (UE overhead) is 100%
  + It was observed by the source that the network and device efficiency can be improved by on-demand PRS (assuming the same latency) compared to periodic PRS
* In one source ([8]), the PRS resource utilization was evaluated for the case of 20 ms DL PRS periodicity, 30 kHz subcarrier spacing, and 12 symbols per PRS resource:
  + PRS with 12 symbols has positioning resource utilization of 2.1 %.

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**Question 8: Any comments on the text proposal on summary of higher layer latency?**

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| **Company** | **Comments** |
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